SMITHSONIAN INSTITUTION LIBRARIES

SMITHSONIAN INSTITUTION LIBRARIES

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 20

1987

HUBERT C. SKINNER

and

EMILY H. VOKES

Editors

TULANE UNIVERSITY OF LOUISIANA

New Orleans

7-4b

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 20, Numbers 1-3 September 16, 1987

LATE MIOCENE AND EARLY PLIOCENE SILICEOUS MICROFOSSILS FROM THE UPPER MONTEREY AND LOWER SISQUOC FORMATIONS, SWEENY ROAD, SANTA BARBARA COUNTY, CALIFORNIA

W. H. AKERS
R. E. MAROLT
R. J. NAVARETTE

CHEVRON OIL FIELD RESEARCH COMPANY
LA HABRA, CALIFORNIA

TULANE UNIVERSITY OF LOUISIANA
New Orleans

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY is devoted primarily to the geology and paleontology of the coasts and adjacent land areas of the Gulf of Mexico and the Caribbean Sea. Each number contains an individual monographic study, or several minor studies. As volumes are completed, title pages and tables of contents will be distributed to subscribers and institutions exchanging the entire series.

Manuscripts submitted for publication are evaluated by the editors and for longer papers by an editorial committee selected from the field of the author(s). Contributors need not be members of the Tulane University faculty.

Manuscripts should be submitted on good paper, as original typewritten copy, double-spaced and carefully corrected. Two carbon copies in addition to the original will help expedite editing and assure more rapid publication.

The cost of excessive illustrations and tabular matter may be charged to the author, and will be computed on the cost above that of a normal 10-point page of text.

An abstract not exceeding three percent of the length of the original article must accompany each manuscript submitted. This will be transmitted to any abstracting journal specified by the writer.

Separate numbers or volumes may be purchased by individuals. Subscriptions are not accepted from institutions publishing comparable series; exchange agreements are invited. Authors may obtain copies for personal use at cost.

Address all communications concerning manuscripts and editorial matters, subscriptions, and orders for individual numbers to the editor. Address exchange inquiries to the exchange director.

When citing this series, authors are requested to use the following abbreviations: *Tulane Stud. Geol. Paleont.*

Price for this number, $15.00

Hubert C. Skinner, *Editor*
Emily H. Vokes, *Editor*
and *Exchange Director*
Tulane Studies in Geology and Paleontology
Department of Geology
Tulane University
New Orleans, Louisiana 70118
U.S.A.

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 20, Numbers 1-3 September 16, 1987

LATE MIOCENE AND EARLY PLIOCENE SILICEOUS MICROFOSSILS FROM THE UPPER MONTEREY AND LOWER SISQUOC FORMATIONS, SWEENY ROAD, SANTA BARBARA COUNTY, CALIFORNIA

W. H. AKERS
R. E. MAROLT
R. J. NAVARETTE

CHEVRON OIL FIELD RESEARCH COMPANY
LA HABRA, CALIFORNIA

Page
Part I, The Geological Setting *by* W. H. Akers 3
Part II, Radiolaria *by* W. H. Akers 11
Part III, Diatoms *by* R. J. Navarrette 39
Part IV, Silicoflagellates *by* R. E. Marolt 85
Bibliography 103

ABSTRACT

Radiolaria, diatoms, and silicoflagellates are identified and illustrated from the late Miocene and Early Pliocene beds of the Monterey and Sisquoc Formations that are exposed along Sweeny Road, near Lompoc, California. The greatest number of species recovered belong to the Bacillariophyceae (diatoms). Radiolaria are second in species abundance and silicoflagellates third. Radiolaria were sometimes found to outnumber diatoms in rocks affected by diagenesis or dissolution. In some intervals, diatoms and silicoflagellates were rare or absent, and only three or four species of Radiolaria, predominantly SPUMELLARIA Ehrenberg 1875, were found. In general, the rocks that were least subjected to diagenesis or dissolution yielded the highest species diversity and the most specimens of all three groups of siliceous microfossils.

EDITORIAL COMMITTEE FOR THIS PAPER:
DAVID BUKRY, U. S. Geological Survey, Menlo Park, California
CATHERINE A. NIGRINI, La Habra, California
HANS JOACHIM SCHRADER, Oregon State University, Corvallis, Oregon

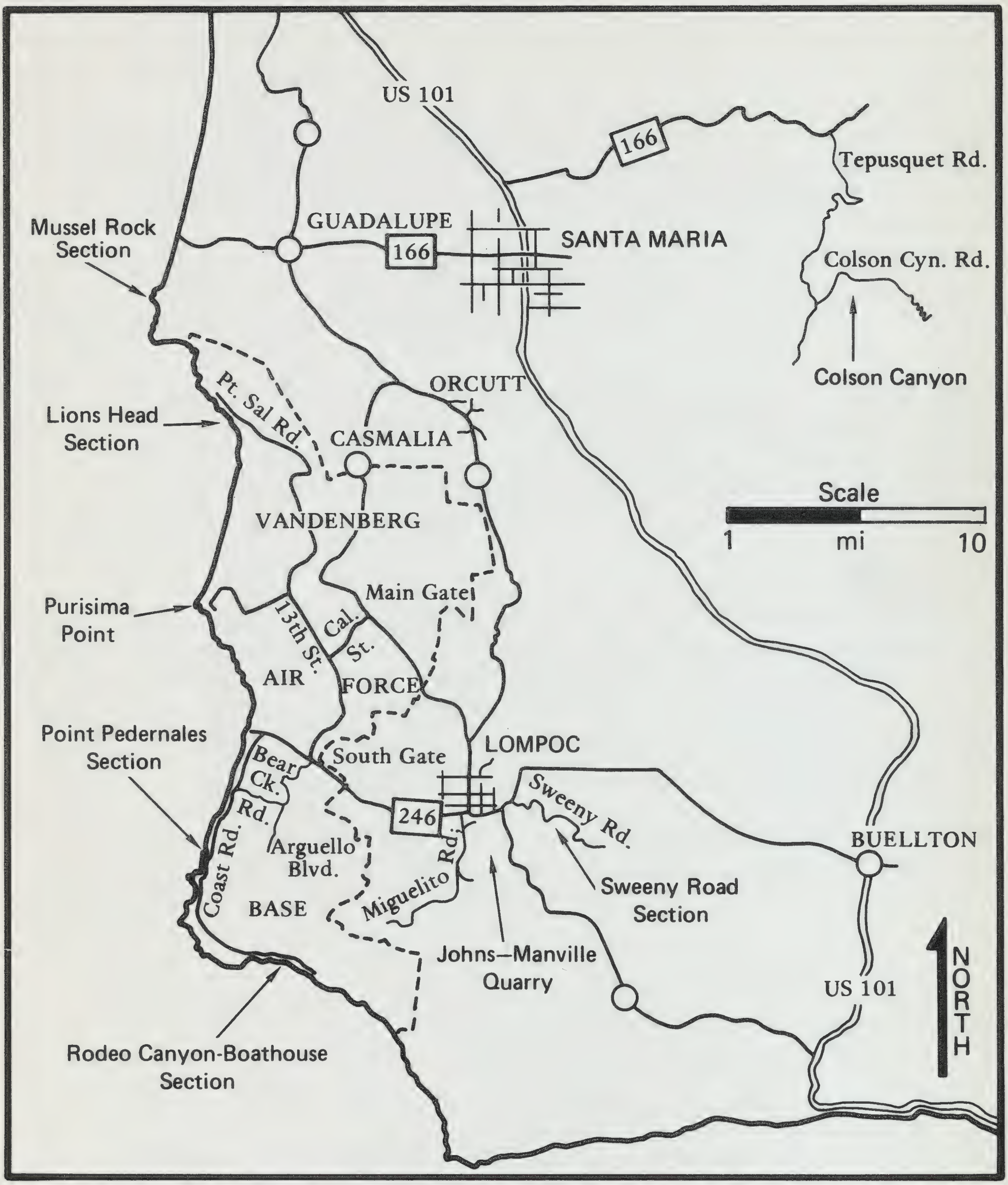


Figure 1. Location map for the Sweeny Road section and other outcrops of the Monterey Formation in the Santa Maria-Lompoc area.

PART I
THE GEOLOGICAL SETTING

W. H. AKERS

CONTENTS

Page
I. INTRODUCTION 3
Location of Study Area
Geologic Setting
Biostratigraphic Framework
Acknowledgments
II. APPENDIX A, Foraminifera *by* K. L. Finger 8
III. APPENDIX B, Palynomorphs *by* S. K. Srivastava 9
IV. APPENDIX C, Siliceous Microfossil Processing *by* Carlton J. Ford 9

I. INTRODUCTION

Radiolaria, diatoms, and silicoflagellates are conspicuous microscopic constituents of the Monterey and Sisquoc formations at Sweeny Road, Santa Barbara County, California, and offer the only substantial means for subdividing the sequence on a biostratigraphic basis. Other fossils have been noted there, including fish scales, fish bones, sponge spicules, foraminifera, and palynomorphs. Summaries on the recovery of foraminifera, and palynomorphs from the section at Sweeny Road are included in the appendices by K. L. Finger (Appendix A) and S. K. Srivastava (Appendix B). Also included is a note on the processing of rocks for siliceous microfossils by Carlton J. Ford (Appendix C).

Location of Study Area

Access to the Sweeny Road section may be accomplished by proceeding north on California Highway 1 to Lompoc. At the "T" intersection with Ocean Avenue (at the Grefco processing plant), turn right on Highway 246 and drive approximately 0.5 mile to Sweeny Road. Turn right and drive two miles to exposures on the north side of the road (see Fig. 1). The locality is at latitude 34° 39-39.5′N., longitude 120° 35.5′W.

The section was measured and sampled by G. L. Armstrong and W. H. Akers (see Figures 2 and 3) on May 11 and 12, 1982. The 73 samples of rock material collected at that time were prepared for radiolarian, diatom, and silicoflagellate microscopy at the Chevron Oil Field Research Company (COFRC) biostratigraphic laboratory by C. J. Ford and G. L. Armstrong.

Geologic Setting

Approximately 1,575 feet (480 meters) of diatomites, cherts, porcellanites, and occasional dolomites are exposed in the road cut along Sweeny Road (Figure 2). The beds strike WNW with variable dips, and the oldest rocks are exposed toward the east. Terrace deposits at the western end of the section conceal the top of the marine sequence. The uppermost portion of the section, as in other exposed sections in the Santa Maria - Santa Barbara area, is considered to be the Sisquoc Formation (Woodring and Bramlette, 1950). The contact between the Sisquoc Formation and the underlying Monterey Formation in this area has been identified by criteria which are elusive in the field (Isaacs, 1981, p. 52). The section is continuously exposed except for three intervals of slumping or erosion of the road bank. Several east-west trending folds repeat part of the section between samples 31 and 36 (see Figures 5 and 6).

The Neogene section exposed along Sweeny Road is divided into two parts by a sequence of folded beds. The 800 feet (244 meters) of section below this folded interval is composed of flaggy, siliceous mudstones interbedded with laminated porcellanites and cherts (Figures 3, 4). The flaggy, siliceous mudstones are usually thin-bedded to laminated and weathered to a dull, chalky appearance, outwardly resembling somewhat hard, buff diatomite. The lower portion of the section was selectively sampled for the softest rocks. Even these yielded only rare siliceous microfossils due to diagenesis. Calcareous microfossils are absent, but fish scales and bones are locally abundant on bedding

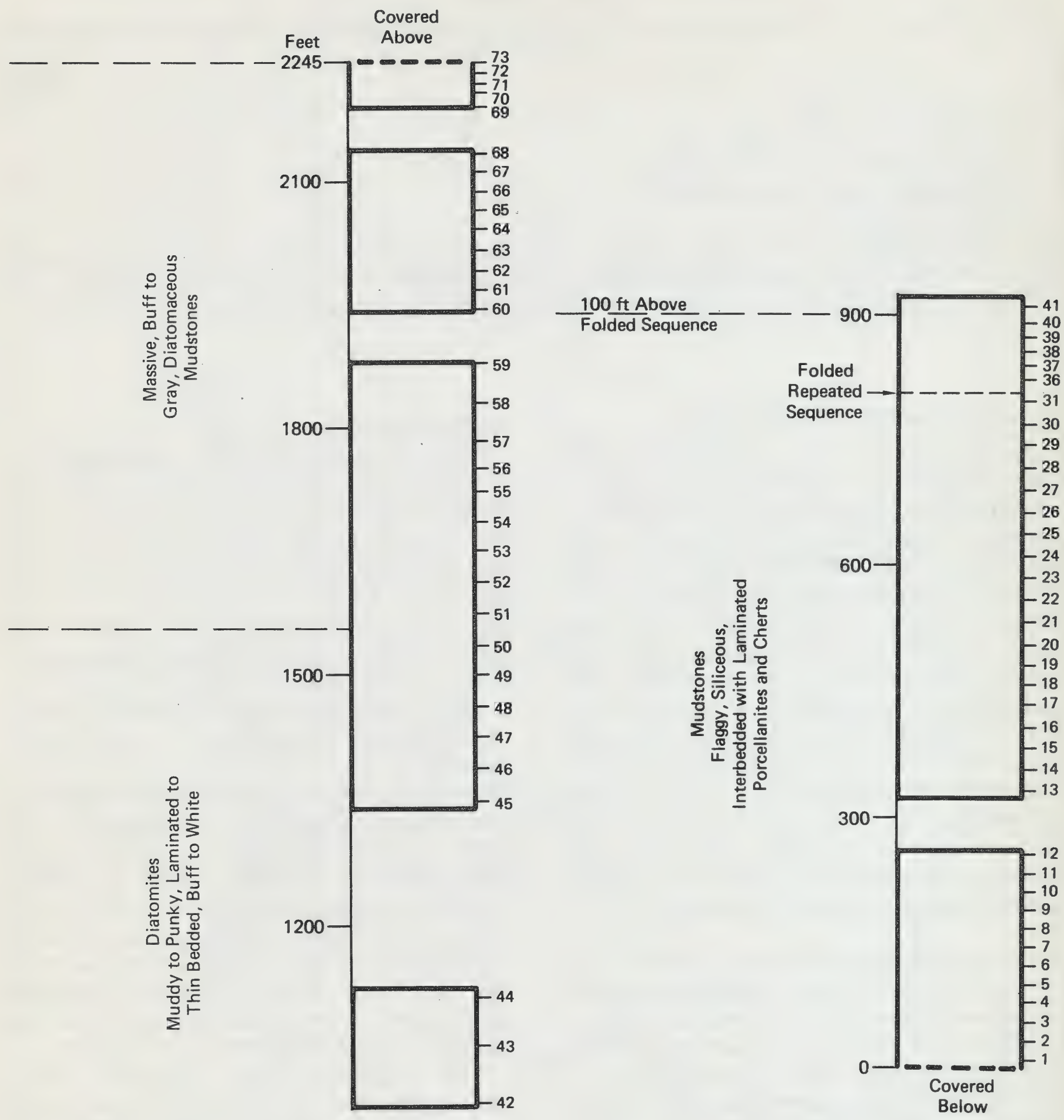


Figure 2. Sweeny Road Section (CRC40396). Relative stratigraphic positions of sampled horizons and major lithologic categories. Covered intervals left blank.

planes. The porcellanites and cherts are thin-bedded to laminated and weathered to a dull, highly fractured and jagged surface. Thin beds of buff-weathering dolomitic porcellanites and dolomites are present but rare.

The 100 feet (30 meters) of beds immediately above the folded and repeated interval are similar to the flaggy, siliceous mudstones, laminated porcellanites, and cherts below the folded zone. Laminated diatomites appear and rapidly increase in abundance to predominate in the sequence from 100 feet (30 meters) above the folded interval to the top of the section. They are muddy to punky and buff to white in color. Diagenetically produced cherts and porcellanites do not occur in the

FIGURE 3
SWEENY ROAD SECTION (CRC40396)
LOG OF SAMPLED HORIZONS

by George L. Armstrong

Sample No.	Feet Above Top of Folded Section
73	1475
72	1459
71	1439
70	1412
69	1385
80′ interval not exposed	
68	1305
67	1279
66	1252
65	1225
64	1200
63	1175
62	1150
61	1125
60	1100
59	1063
58	1038
57	1018
56	993
55	975
54	946
53	917
52	888
51	859
50	830
49	789
48	755
47	710
46	674
45	650
390′ interval not exposed	
44	260
43	225
42	189
41	121
40	100
39	76
38	55
37	31
36	0
Folded Section	

Sample No.	Feet Above Base of Exposed Section
31	800
30	779
29	763
28	745
27	715
26	684
25	642
24	621
23	591
22	565
21	536
20	510
19	481
18	448
17	415
16	390
15	359
14	338
13	320
60′ interval not exposed	
12	260
11	240
10	219
9	204
8	183
7	162
6	141
5	120
4	90
3	60
2	30
1	0
Base of Section	

Figure 4. View of the exposures along Sweeny Road, looking south from near the top of the section. The oldest beds are near the right-hand margin of the photograph.

interval between 190 feet (58 meters) above the folded beds and the top of the exposure.

The upper portion of the section at Sweeny Road is referable to the Sisquoc Formation. Most of the underlying Monterey Formation fits the lithologic subdivision variously referred to as the "Upper Member" (Arnold and Anderson, 1907; Woodring and Bramlette, 1950) and the "Siliceous Member" (Isaacs, 1981, Fig. 23; Pisciotto, 1978). A thin, lowermost interval is referable to the upper part of the "Lower Member" of Arnold and Anderson (1907), the upper part of the "Middle Member" of Woodring and Bramlette (1950), and the upper part of the "Upper Calcareous Member" of Isaacs (1981). The "Siliceous Facies" of Pisciotto (1978) would include the entire Monterey sequence exposed at Sweeny Road.

Biostratigraphic Framework

The siliceous sequences at Sweeny Road can be correlated with several published sequences. One of these is at Site 173 of DSDP Leg 18 (off Cape Mendocino, California) approximately 449 miles (722 kms) northwest of Sweeny Road. The Newport Bay section, cited below, is approximately 159 miles (256 kms) southeast of the subject locality, and Site 469, DSDP Leg 63, is approximately 145 miles (233 kms) southwest of Sweeny Road.

Mixing of equatorial and high-latitude assemblages were noted at Site 173 by Kling (1973, p. 618), who employed radiolarian zonations proposed for both regions where applicable. He recognized the equatorial Miocene zones of Riedel and Sanfilippo (1970, p. 512, 513; 1971, p. 1549, 1580) but could not determine their boundaries. The nominate species of Kling's composite zones for the Miocene at Site 173, in ascending order, are *Calocycletta costata, Dorcadospyris alata, Diartus petterssoni, Didymocyrtis antepenultima*, and *Stichocorys peregrina* (see Kling, 1973, Fig. 1).

The base of the Pliocene in the Pacific Coast region has been associated with the earliest appearance of *Lamprocyrtis heteroporos* (Hays), and it is on this basis that Kling (1973, p. 618, Fig. 1) recognized

Figure 5. View of interbedded porcellanites, cherts, and diatomaceous mudstones from about the middle of the Sweeny Road section.

Figure 6. Close-up view of laminated diatomites with the first appearance of diagenetic chert nodules.

the Miocene-Pliocene boundary at Site 173. The earliest occurrence of this species in the Newport Bay section approximates the boundary (Weaver *et al.*, 1981, Fig. 2) and dovetails with the interpretation of Ingle (1967, 1972) for the Miocene-Pliocene boundary using foraminifera from the Newport Bay outcrops. This horizon was also identified by Casey *et al.* (1972, p. 226) in the section at Malaga Cove, California. According to Kling (1973, p. 618, Fig. 1), the base of the Upper Pliocene *Lamprocyrtis heteroporos* Zone at Site 173 coincides with the uppermost occurrence of *Stichocorys peregrina* (Riedel), as defined by Hays (1970, p. 195), with a radiometric-paleomagnetic age of 2.8 m.y. Further, Kling adds, "this leaves a segment of time from the Miocene-Pliocene boundary to the base of the *L. heteroporos* Zone representing part of the *Spongaster pentas* Zone of Riedel and Sanfilippo (1970, p. 513) but not recognizable in this region."

The portion of the Sweeny Road section that yielded identifiable diatoms suggests that this fossiliferous sequence includes the North Pacific zones of Schrader (1973) from Zone VII to Zone X and the Northeastern Pacific zones of Barron (1981) from the *Denticulopsis seminae* var. *fossilis-D. kamtschatica* Zone down to the *Nitzschia reinholdii* Zone.

The model, thus constructed for Site 173 and Newport Bay, identifies the Sweeny Road section as Upper Miocene to Pliocene in age. Exactly how much of the Pliocene is represented by the section remains open to question, but it is precisely correlatable with the upper part of the *Stichocorys peregrina* Zone and the lower part of the *Lamprocyrtis heteroporos* Zone as proposed for Site 173 (Kling, 1973, Fig. 1).

The correlation of sedimentary sequences can be complicated by recycled fossils and hiatuses. The latter phenomenon has been recognized in Pacific regions by several biostratigraphers (Keller, Barron, and Burckle, 1982; Barron and Keller, 1983; and Keller and Barron, 1983) using a multidisciplinary approach. Thus, the apparent first and last appearances of microfossils in the Sweeny Road beds, or in any other section, may not necessarily be the true first and last appearance datums of the respective forms. Correlation of Monterey strata, therefore, should be proposed with consideration of the regional depositional history and as much biostratigraphic detail as available.

Acknowledgments

Chevron Oil Field Research Company (COFRC) fully supported the research for these reports, and we thank our associates, K. L. Finger, S. K. Srivastava, C. J. Ford, G. L. Armstrong and K. N. Kirwan for additional biostratigraphic data, sample collection and processing, and computer generation of occurrence charts. T. C. Mac Kinnon furnished valuable field guidance, lithologic data, and the photographs reproduced for this report. In particular, we thank H. J. Schrader, C. A. Nigrini, W. R. Riedel, and D. Bukry who contributed invaluable literature and expertise within their respective disciplines. The project was conceived and supported by Drew Haman.

II. APPENDIX A

FORAMINIFERA

K. L. FINGER

Twenty-five samples from the Sweeny Road section were examined: CRC40396-1, 5, 9, 13, 17, 21, 25, 29, 36, 40, 44, 48, 52, 56, 60, 64, 65, and 67 through 73. Although diatoms and radiolarians were observed in the washed residues, foraminifera and other calcareous microfauna (*e.g.*, ostracodes) were conspicuously absent throughout the 2,245-foot (685 meters) section, except in Sample 66. This sample, which is from the Sisquoc Formation, yielded only two poorly-preserved specimens similar to *Nonionella* cf. *N. davanaensis* Pierce *sensu* Warren, a form which has been recorded from the Late Mohnian interval of the Monterey Formation at Newport Lagoon. Its full range is unknown.

The highly siliceous nature of these rocks suggests that the overall rarity of foraminifers has not been biased by their disintegration in laboratory processing. Two thin sections of Sample 66 were made, one parallel and one perpendicular to the laminations, but neither contained any foraminifers nor fragments thereof.

III. APPENDIX B
SWEENY ROAD PALYNOMORPHS
S. K. SRIVASTAVA

CRC40396-4: Several vesicles of *Rhizophagites* occurred. Modern fungi similar to *Rhizophagites* grow inside the roots of many plants. These could be modern contamination. No palynomorphs seen.

CRC40396-12: *Pterospermella* (11 specimens), rare occurrence of degraded unidentified chorate dinocysts.

CRC40396-20: Palynomorphs - none.

CRC40396-31: Two damaged specimens of *Pterospermella*.

CRC40396-39: Palynomorphs - none.

CRC40396-48: Palynomorphs - none.

CRC40396-56: *Pterospermella* (10 specimens), abundant brownish-black foraminifer chambers (chitinous linings).

CRC40396-67: *Pterospermella* (6 specimens), several broken *Tytthodiscus*, two bisaccate *Pinus* pollen.

IV. APPENDIX C
SILICEOUS MICROFOSSIL PROCESSING, SWEENY ROAD SECTION, MONTEREY FORMATION
CARLTON J. FORD

The top of the Sweeney Road Section posed no significant problem for processing and recovering siliceous microfossils. Samples 73 through 39 were generally light buff, laminated diatomaceous mudstones. These rocks were processed as described in Procedure #1 (below). Any remaining sample that did not break down was then processed by using the potassium hydroxide method as described in Procedure #2 (below).

Samples 38 through 1 were generally buff, siliceous mudstones with some porcellaneous mudstones present. These samples would not readily break down using the H_2O_2-$Na_4P_2O_7$ method. What material that did break down was still encapsulated in clays. The first procedure was bypassed, and we had great success breaking down the remaining material using Procedure #2.

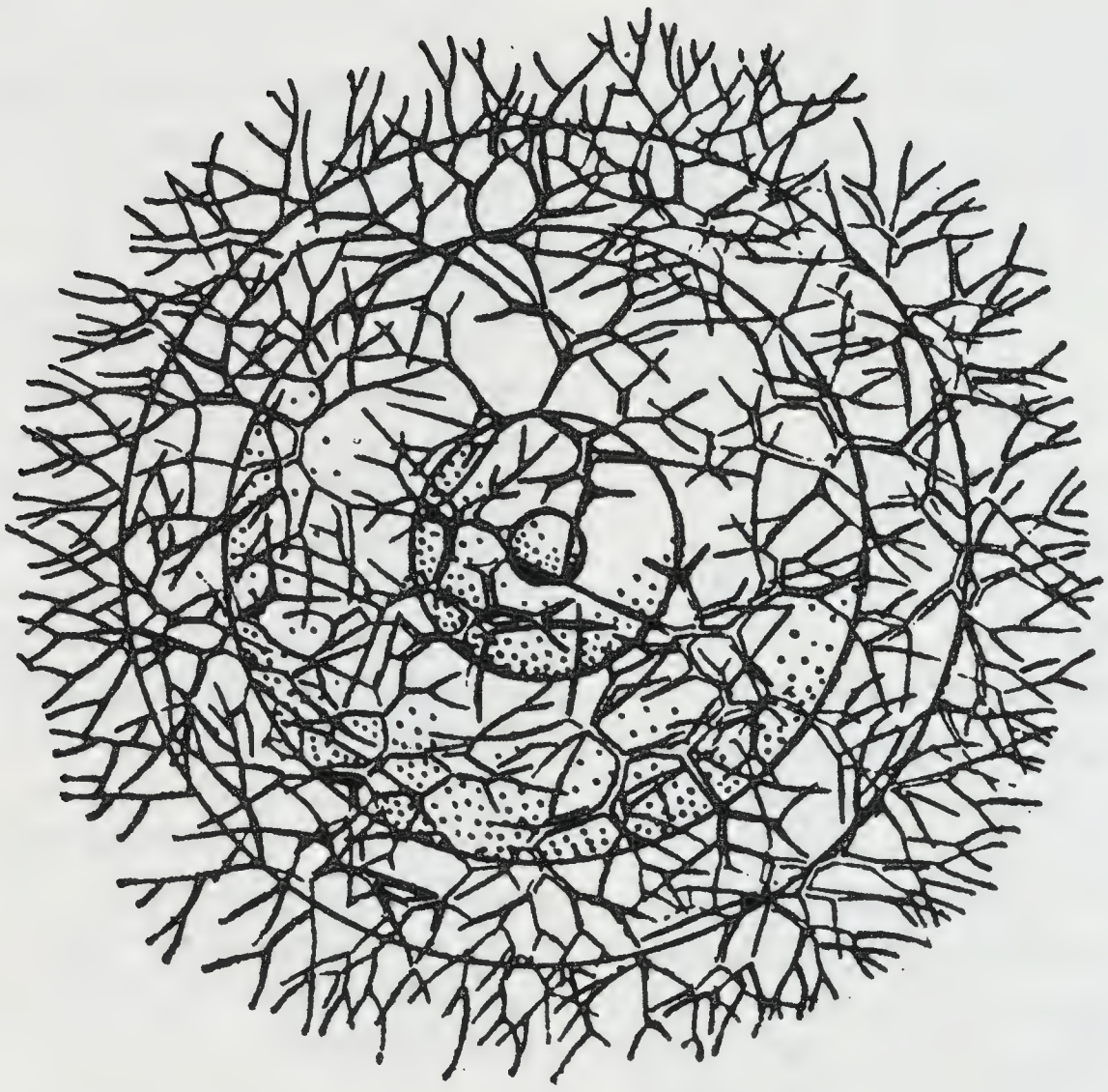
However, one must be very careful while using potassium hydroxide. It is a very harsh basic solution. It is possible that some borderline diagenetic silica can be dissolved by it, including small diatoms and silicoflagellates.

SILICEOUS MICROFOSSIL PROCESSING PROCEDURE #1 FOR DIATOMITES, OOZES, MUDS, SANDSTONES:

1. Boil 5-25 grams of sample in 150 mls of hydrochloric acid for 15 minutes.
2. Rinse the HC1 out of sample by decanting every 30 minutes, or centrifuge the sample until neutral.
3. Place the remaining sample into 250 mls of H_2O and add H_2O_2 with an eyedropper to facilitate an agitating reaction. Some samples of the lithologies above tend to break down more cleanly and faster, if the 250 mls of H_2O is substituted with 100 mls of hydrogen peroxide.
4. Add .5 grams of sodium pyrophosphate.
5. Boil the sample and keep adding H_2O_2 until the sample breaks down.
6. Decant or centrifuge the sample to rinse out any H_2O_2 which may have remained.
7. Sieve +63 and +28 micron fractions and thoroughly rinse with water.
8. Place the remaining sample in a 400 ml beaker with .5 grams of hexameta phosphate (Calgon) and water to help suspend the clays and supernatants for the -28 micron fraction.
9. The remaining -28 micron fraction should then be decanted every hour until clear.

PROCEDURE #2 FOR DOLOMITIC, SILICEOUS, AND PHOSPHATIC SHALES:

1. Crush 5-25 grams of sample until chips are 3 to 6 mm (1/8 to 1/4 in.) in diameter.
2. Boil the sample in 250 mls of Aqua Regia for 15-30 minutes.
3. Centrifuge the sample until neutral.
4. Place the sample into a hot solution of 50-100 mls of <5% Potassium Hydroxide.
5. Boil the sample for not longer than 15-20 minutes and add H_2O_2 slowly, using an eyedropper.
6. Centrifuge the sample until neutral, leaving behind in the beaker the larger granules which did not break down.
7. Follow steps 7 through 9.



PART II
RADIOLARIA

W. H. AKERS

CONTENTS

Page
I. INTRODUCTION 11
II. SYSTEMATIC PALEONTOLOGY 12

ILLUSTRATIONS

PLATES 1-10 . . . . . beginning on page 14
CHECK CHART I, Radiolarians (alphabetized) 35
CHECK CHART II, Radiolarians (last appearance datum) 36
CHECK CHART III, Radiolarians (first appearance datum) 37

I. INTRODUCTION

Objectives Of Study

This report is intended as a survey and preliminary inventory of the Radiolaria in the section exposed along Sweeny Road. The identification of many species will be practical only after they are studied as components of lineages within their respective families, after the monographic treatment of families on a world-wide basis. The data contributed herein on faunas from Sweeny Road will merely indicate taxonomic groups that require such massive systematic research for an understanding of radiolarian biostratigraphy. A few of the species identified at Sweeny Road offer useful first and last appearance datums to which paleomagnetic ages and radiometric dates have been assigned by Deep Sea Drilling Project (DSDP) scientists.

Background

Formations of coastal California have been neglected for their radiolarian faunas since the epic report by Campbell and Clark (1944) on assemblages from the Palos Verdes Hills and the Newport Bay area. Recent interest in the Monterey Formation has been stimulated by petroleum discoveries offshore of Point Conception and Point Arguello. The biogenic origin of the reservoir rock, which may also have been the source beds for this new prolific production, has revived an interest in the organisms that were responsible for so much sediment accumulation in the Santa Maria basin. Radiolaria are a conspicuous component of the diatomaceous portions of the Monterey Formation, and in some beds they even outnumber diatoms, due to the greater resistance of their skeletons to diagenesis than provided by the hollow skeletal elements of diatoms. It is not surprising, then, that some biostratigraphers are taking another look at the siliceous microfossils of the California Neogene with particular interest in stratigraphic and paleoceanographic implications (Weaver *et al.*, 1981).

Fortunately for the use of Radiolaria in geochronology and stratal correlation, a few research centers have continued since 1944 to support not only biostratigraphic research, but also multidisciplinary approaches to geochronology. Thereby, the DSDP has produced refinements in the taxonomy of planktic microfossils and a global model for marine stratigraphy. Thus, radiolarian research, as well as studies on other microplankton, although represssed on land, is alive and well in the deep sea. It is largely due to the comprehensive scope of DSDP reports that constituents of our land-based faunas can be identified with species that are variously termed "tropical", "subpolar", or "tropical submergent." Publication of *Cenozoic Radiolarian Stratigraphy* (Sanfilipo *et al.*, in press) and *A Guide to Miocene Radiolaria* (Nigrini and Lombari, 1984) will clarify the potential of Radiolaria for marine geochronology. Nevertheless, problems will continue to exist in the identification of Radiolaria on the species level until additional monographic data for families are available, such as Nigrini (1977) contributed on the tropical genera and species of the Cenozoic Artostrobiidae. The identification of lineages in the fossil record, such as those contained in the above reports, will be particularly useful to stratigraphic paleontologists.

The diversity and number of radiolarian species in the Sweeny Road section are less than half of the concentrations found in the tropics, although some of the species from Sweeny Road are abundant at tropi-

cal Neogene sites. This observation is reconcilable with both (1) the higher species diversity in the tropics than in high latitudes, and (2) a diminution of diversity and numbers of individuals in nearshore waters of all oceans and seas of normal marine salinity (Sanfilippo, Westberg-Smith, and Riedel, in press).

Most faunas from the Sweeny Road section are dominated by Spumellarians. Two factors may have contributed to this relationship. The first one is an assumption that certain spongy Spumellarians (with closely related modern descendants) dominated Neogene water masses near land, as they do today on the shelf of the western part of the Bering Sea (Blueford, 1983, p. 769). The second factor for some of the beds is the greater resistance of the spongy type of skeleton to diagenesis than the more delicate skeletons of most Nassellarians.

The fossil radiolarian faunas in the Sweeny Road section are obviously of different species composition than they were in life. Since these organisms lived mostly in the upper few hundred meters of the water column, the more delicate skeletons originating near the sea surface dissolved during their descent to the sea floor, resulting in a concentration of the more robust forms on the sea bottom. Dissolution continued there until burial somewhere in excess of 10-20 cm. Further destruction occurred by diagenesis with progrressive depth of burial until only the most robust and corrosion resistant types survived, and these, too, are absent in the older portions of subsurface and outcropping sections, except for some of the dolomites, in which diagenesis proceeded at a slower rate than in diatomites. Thus, various aspects of siliceous microfossil assemblages were seen in the Sweeny Road section, from those rich in radiolarian, diatom, and silicoflagellate individuals, to those of lower species diversity but with abundant robust radiolarian and diatom individuals, to those with only a few species of robust radiolarians, and finally to rocks barren of all fossil structures. Fortunately, a stratum near the base of the section at Sweeny Road yielded several species of Radiolaria, including the large, corrosion-resistant *Stichocorys peregrina* by which the maximum age of the Monterey Formation exposed here may be concluded to be Late Miocene.

Illustrations

All illustrations are Polaroid prints from type 667 film. The species designation for each figure is followed by the horizon (sample) number, the magnification, and SEM, if a scanning electron micrograph was used. The +63 micron fraction was used for all slides, except when otherwise noted. The prefix, CRC40396, was assigned to all samples collected from the Sweeny Road section, but most references to horizons and samples in this report are cited without the prefix. For example, sample horizon 39, as shown for some of the figures, is an abbreviation for CRC40396-39.

II. SYSTEMATIC PALEONTOLOGY

Since the objective of this paper is to inventory the radiolarians in the Sweeny Road section, my first concept of the taxonomic section was as an informal catalog of species under alphabetical genera without regard to supergeneric categories. This format is followed in the organization of the check charts, but the systematics are primarily that of Nigrini and Lombari (1984).

Subclass RADIOLARIA Müller, 1858
Order POLYCYSTINA Ehrenberg, 1838, emend. Riedel, 1967b
Suborder SPUMELLARIA Ehrenberg, 1875
Family ACTINOMMIDAE Haeckel, 1862, emend. Sanfilippo and Riedel, 1980

Genus ACTINOMMA Haeckel, 1860, emend. Nigrini, 1967, emend. Bjorklund, 1977
ACTINOMMA spp.
Pl. 1, fig. 1

Actinomma spp., NIGRINI and LOMBARI, 1984, p. S13-S14, pl. 2, fig. 1a-d.

Specimens referable to the "species group" described by Nigrini and Lombari (1984) were observed throughout the fossiliferous portions of the section. The group occurs throughout Miocene sections in both tropical and temperate latitudes, but it is more common in temperate than in tropical latitudes, according to these au-

thors. The group may be comprised of several species that do not have stratigraphic utility within the late Neogene.

Genus AXOPRUNUM Haeckel, 1887

AXOPRUNUM ANGELINUM (Campbell and Clark)
Pl. 1, fig. 5, 6

Stylosphaera angelina CAMPBELL and CLARK, 1944, p. 12, pl. 1, fig. 14-20.
Stylatractus universus HAYS, 1970, p. 215, pl. 1, fig. 1, 2; KLING, 1971, p. 1086, pl. 1, fig. 7.
Stylatractus sp. HAYS, 1965, p. 167, pl. 1, fig. 6.
Axoprunum angelinum (Campbell and Clark), KLING, 1973, p. 634, pl. 6, fig. 16, 18; WEAVER *et al.*, 1981, pl. 3, fig. 3, 4.

See Nigrini and Lombari (1984, p. S27-S30, pl. 4, fig. 3a-b) for a discussion of the *Stylatractus universus-Axoprunum angelinum* problem. At Site 173, Leg 18, specimens assigned to this group were identified in Early Miocene to Early Pleistocene sediments.

Genus CROMYDRUPPOCARPUS Campbell and Clark, 1944

CROMYDRUPPOCARPUS ESTERAE Campbell and Clark
Pl. 1, fig. 7, 8

Cromydruppocarpus esterae CAMPBELL and CLARK, 1944, p. 20, pl. 2, fig. 26-28; WEAVER *et al.*, 1981, p. 73, pl. 2, fig. 3.

This is one of five characteristic species of the *Theocorys redondoensis* assemblage, according to Weaver *et al.* (1981, p. 73).

Genus HEXACONTIUM Haeckel, 1781

HEXACONTIUM spp.
Pl. 1, fig. 2, 3

Hexacontium spp. NIGRINI and LOMBARI, 1984, p. S19-S20, pl. 3, fig. 2a-d.

Nigrini and Lombari (1984, p. S20) found specimens assignable to this group throughout most of their Miocene sections from both tropical and temperate latitudes. More than a single species may have been included in the statistical notations on the check charts, but the group does not have stratigraphic utility in the Miocene-Pliocene sequence at Sweeny Road.

Genus LITHATRACTUS Haeckel, 1887

LITHATRACTUS TIMMSI Campbell and Clark
Pl. 1, fig. 4a-b

Lithatractus timmsi CAMPBELL and CLARK, 1944, p. 18, pl. 2, fig. 18, 19; WEAVER *et al.*, 1981, pl. 4, fig. 3, 4.

The uppermost occurrence of this species in the Newport Bay section is in the Upper Miocene at approximately 6.0 Ma (Weaver *et al.*, 1981, fig. 2).

Family SPONGURIDAE Haeckel, 1862, emend. Petrushevskaya, 1975

Genus SPONGURUS Haeckel, 1860

SPONGURUS (?) sp.
Pl. 1, fig. 9

The shell is elliptical in outline as in *Larnacantha polyacantha*, but concentric layers are clearly visible. The species does not appear to have stratigraphic utility.

Family SPONGODISCIDAE Haeckel, 1862, emend. Riedel, 1967b

Genus CIRCODISCUS Kozlova, 1972

CIRCODISCUS MICROPORUS (Stohr)
Pl. 1, fig. 10

Trematodiscus microporus STOHR, 1880, p. 108, pl. 4, fig. 17.
Porodiscus microporus (Stohr). HAECKEL, 1887, p. 493.
Circodiscus microporus (Stohr). PETRUSHEVSKAYA and KOZLOVA, 1972, p. 526, pl. 19, fig. 1-7.
Xiphospira sp. cf. *X. circularis* (Clark and Campbell) *sensu* KLING, 1973, p. 635, pl. 7, fig. 17 (only).
Circodiscus microporus (Stohr) group. NIGRINI and LOMBARI, 1984, p. S73-S74, pl. 10, fig. 3.

Sweeny Road specimens are typical. They are not as abundant as most other Spongodiscidae.

Genus HYMENIASTRUM Ehrenberg, 1847

HYMENIASTRUM spp.
Pl. 2, fig. 1, 2

Hymeniastrum spp. NIGRINI and LOMBARI, 1984, p. S61-S62, Pl. 8, fig. 2a-b.

Whether specimens from Sweeny Road belong to several species or to a single variable species is not clear.

Genus SPONGOCORE Haeckel, 1887

SPONGOCORE PUER Campbell and Clark
Pl. 2, fig. 4, 5

Spongocore puer CAMPBELL and CLARK, 1944, p. 22, pl. 3, fig. 7.
Spongurus smithi CAMPBELL and CLARK, 1944, p. 21, pl. 3, fig. 4.

The two forms of Campbell and Clark will not be differentiated, unless further study indicates morphologic or stratigraphic justification. Study of *Spongocore puella* Haeckel from the Neogene of the South Pacific may show that both species of Campbell and Clark fall within the range of variation for Haeckel's species.

Genus SPONGOPYLE Dreyer, 1889

SPONGOPYLE OSCULOSA Dreyer
Pl. 2, fig. 3, 7

Spongopyle osculosa DREYER, 1889, p. 42, pl. 11, fig. 99, 100; RIEDEL, 1958, p. 226, pl. 1, fig. 12; NIGRINI and MOORE, 1979, p. S115, pl. 16, fig. 1; NIGRINI and LOMBARI, 1984, p. S77-S78, pl. 11, fig. 1a-b.
Spongodiscus(?) *osculosus* (Dreyer). PETRUSHEVSKAYA, 1967, p. 42, fig. 20-22.

Spongopyle osculosa has been reported throughout the Miocene in both tropical and temperate latitudes (Nigrini and Lombari, 1984, p. S78). Nigrini and Moore (1979, p. S116) discussed Holocene distribution.

Genus SPONGOTROCHUS Haeckel, 1860

SPONGOTROCHUS GLACIALIS Popofsky group
Pl. 2, fig. 6, 8

Spongotrochus glacialis POPOFSKY, 1908, p. 228, pl. 26, fig. 8; pl. 27, fig. 1; pl. 28, fig. 2; RIEDEL, 1958, p. 227, pl. 2, fig. 1, 2, text-fig. 1.
Spongotrochus glacialis Popofsky group. PETRUSHEVSKAYA, 1975, p. 575, pl. 5, fig. 8; pl. 35, fig. 1-6 (with synonymy); NIGRINI and MOORE, 1979, p. S117, pl. 15, fig. 2a-d.
Spongodiscus gigas CAMPBELL and CLARK, 1944, p. 27, pl. 4, fig. 1, 3.
Stylotrochus sol CAMPBELL and CLARK, 1944, p. 28, pl. 4, fig. 7, 9, 10, 11.

The two species of Campbell and Clark are gradational, long ranging (Miocene to Holocene), and there is no morphologic or stratigraphic basis for differentiating them.

SPONGOTROCHUS(?) VENUSTUM (Bailey)
Pl. 3, fig. 1

Perichlamydium venustum BAILEY, 1856, p. 5, pl. 1, fig. 16, 17.
Stylochlamydium venustum (Bailey). HAECKEL, 1887, p. 515.
Perichlamydium scutaeforme CAMPBELL and CLARK, 1944, p. 24, pl. 3, fig. 14-16.
Spongotrochus(?) *venustum* (Bailey). NIGRINI and MOORE, 1979, p. S119, pl. 15, fig. 3a-b.

This form ranges thrughout the Monterey Formation and varies in shell outline form elliptical to circular; the edge is sometimes entire but may have spines extending from the central part slightly beyond the periphery.

Genus STYLODICTYA Ehrenberg, 1847, emend. Kozlova, 1972

STYLODICTYA VALIDISPINA Jørgensen
Pl. 3, fig. 4, 7

Stylodictya validispina JØRGENSEN, 1905, p. 119, pl. 10, fig. 40; PETRUSHEVSKAYA, 1967, p. 33, fig. 17, IV-V; NIGRINI and MOORE, 1979, p. S103, pl. 13, fig. 5a-b; NIG-

---

PLATE 1

1. *Actinomma* sp. 67, x320.
2. *Hexacontium* sp. 39, x275.
3. *Hexacontium* sp. 39, x275.
4a-b. *Lithatractus timmsi* Campbell and Clark. 43, x320, the same specimen at different levels of focus.
5. *Axoprunum angelinum* (Campbell and Clark). 39, x200.
6. *Axoprunum angelinum* (Campbell and Clark). 39, x250.
7. *Cromydruppocarpus esterae* (Campbell and Clark). 39, x250.
8. *Cromydruppocarpus esterae* (Campbell and Clark). 69, x565, SEM.
9. *Sponguras*(?) sp. 71, x400.
10. *Circodiscus microporus* (Stohr). 54, x320.

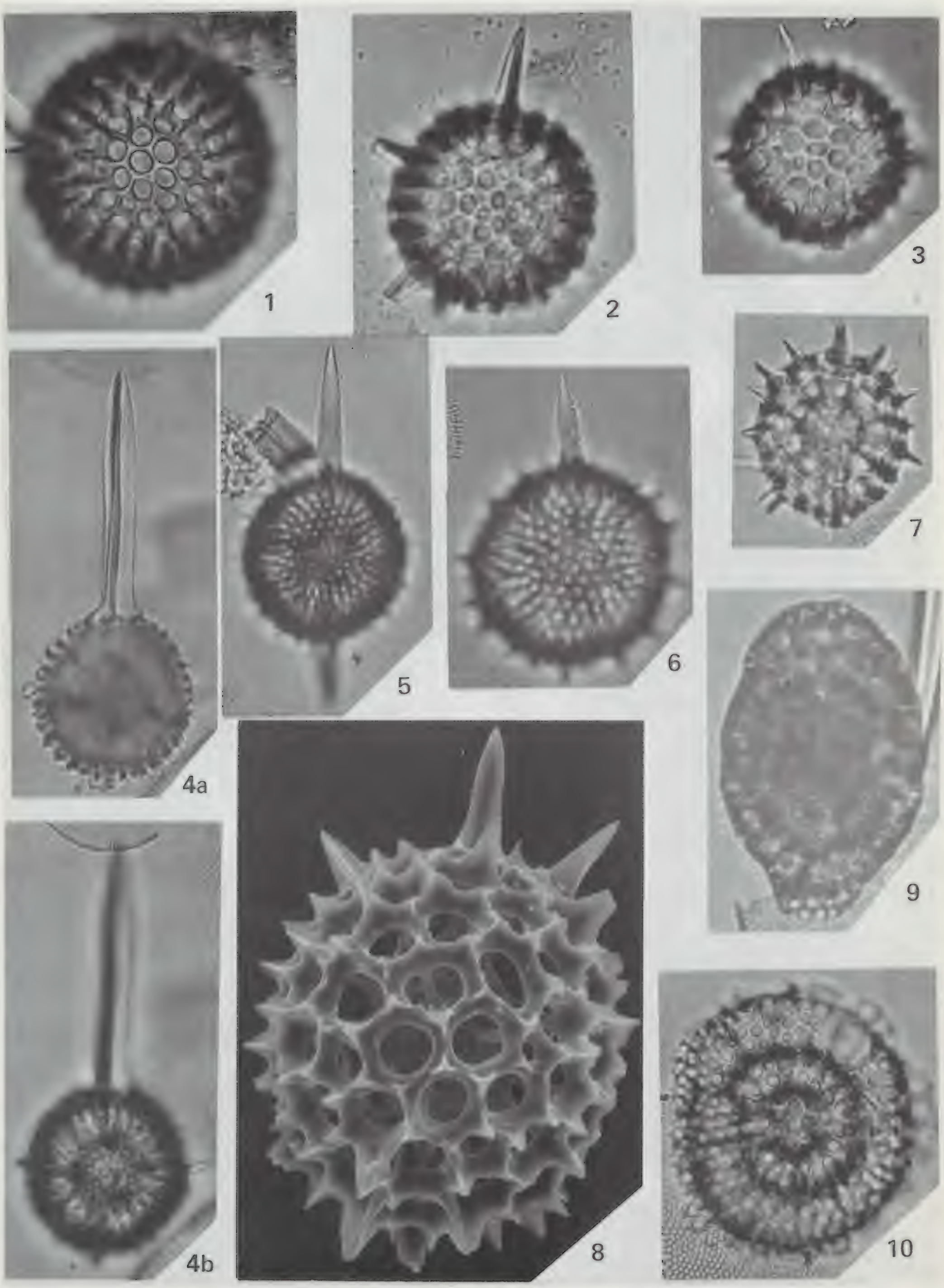


PLATE 1

RINI and LOMBARI, 1984, p. S71, pl. 10, fig. 2 (with morphologic and distribution notes).

Early Miocene to Holocene in both tropical and temperate latitudes (Nigrini and Lombari, 1984, p. S72).

Genus XIPHOSPIRA Haeckel, 1887

XIPHOSPIRA sp. cf. X. CIRCULARIS (Clark and Campbell)
Pl. 3, fig. 2, 3

Porodiscus circularis CLARK and CAMPBELL, 1942, p. 42, pl. 2, fig. 2, 6, 10.
Xiphospira circularis (Clark and Campbell). SANFILIPPO and RIEDEL, 1973, p. 526, pl. 14, fig. 5-12; pl. 31, fig. 4-7.
Xiphospira sp. cf. *X. circularis* (Clark and Campbell). KLING, 1973, p. 635, pl. 2, fig. 1-3; pl. 7, fig. 11-17.
Xiphodictya amphixiphos CLARK and CAMPBELL, 1942, p. 43, pl. 2, fig. 4.
(?)*Stylodictya heliozoides* CAMPBELL and CLARK, 1944, p. 25, pl. 3, fig. 17.
(?)*Stylodictya camerina* CAMPBELL and CLARK, 1944, p. 26, pl. 3, fig. 18, 19, 21.
(?)*Stylodictya ornata* CAMPBELL and CLARK, 1944, p. 26, pl. 3, fig. 20.
(?)*Stylodictya cornuspira* CAMPBELL and CLARK, 1944, p. 27, pl. 3, fig. 22.

The broad concept of this species adopted by Sanfilippo and Riedel (1973, p. 526) is employed here. As so interpreted, the group ranges throughout the Monterey Formation.

Family PYLONIIDAE Haeckel, 1881

Genus PHORTICIUM Haeckel, 1881

PHORTICIUM POLYCLADUM Tan and Tchang
Pl. 3, fig. 9, 11

Phorticium polycladum TAN and TCHANG, 1976, p. 267, text-fig. 39-a-b; NIGRINI and LOMBARI, 1984, p. S83, pl. 12, fig. 1a-b.

This species has been reported common to abundant in Miocene sections from both tropical to temperate latitudes (Nigrini and Lombari, 1984, p. S84). If occurrences in the East China Sea (Tan and Tchang, 1976, p. 267) are Holocene, the range is at least as far back as Early Miocene to Holocene.

Family LITHELIIDAE Haeckel, 1862

Genus LARCOSPIRA Haeckel, 1887

LARCOSPIRA QUADRANGULA Haeckel
Pl. 3, fig. 8

Larcospira quadrangula HAECKEL, 1887, p. 696, pl. 49, fig. 3; BENSON, 1966, p. 266, pl. 13, fig. 7-8; NIGRINI and MOORE, 1979, p. S133, pl. 17, fig. 2.
Larcospira quadrangula Haeckel group. NIGRINI and LOMBARI, 1984, p. S93-S94, pl. 13, fig. 3a-c.

The species group was recorded by Nigrini and Lombari (1984, p. S94) from both tropical (common to abundant) and temperate (rare) latitudes. It has also been found in Holocene material (Nigrini and Moore, 1979, p. S134).

Genus LITHELIUS Haeckel, 1862

LITHELIUS MINOR Jørgensen
Pl. 3, fig. 10

Lithelius minor JØRGENSEN, 1900, p. 65, pl. 5, fig. 24; BENSON, 1966, p. 262, pl. 17, fig. 10 (only); NIGRINI and MOORE, 1979, p. S135, pl. 17, fig. 3, 4a-b.
Larcospira minor (Jørgensen). JØRGENSEN, 1905, p. 121.

See remarks under *L. nautiloides*.

LITHELIUS NAUTILOIDES Popofsky
Pl. 3, fig. 5, 12

Lithelius nautiloides POPOFSKY, 1908, p. 230, pl. 27, fig. 4 (only); RIEDEL, 1958, p. 228, pl.

PLATE 2

1. *Hymeniastrum* sp. 73, x320.
2. *Hymeniastrum* sp. 42, x240.
3. *Spongopyle osculosa* Dreyer. 62, x320.
4. *Spongocore puer* Campbell and Clark. 48, x250.
5. *Spongocore puer* Campbell and Clark. 43, x250.
6. *Spongotrochus glacialis* Popofsky Group. 39, x250.
7. *Spongopyle osculosa* Dreyer. 42, x320.
8. *Spongotrochus glacialis* Popofsky Group. 60, x276, SEM.

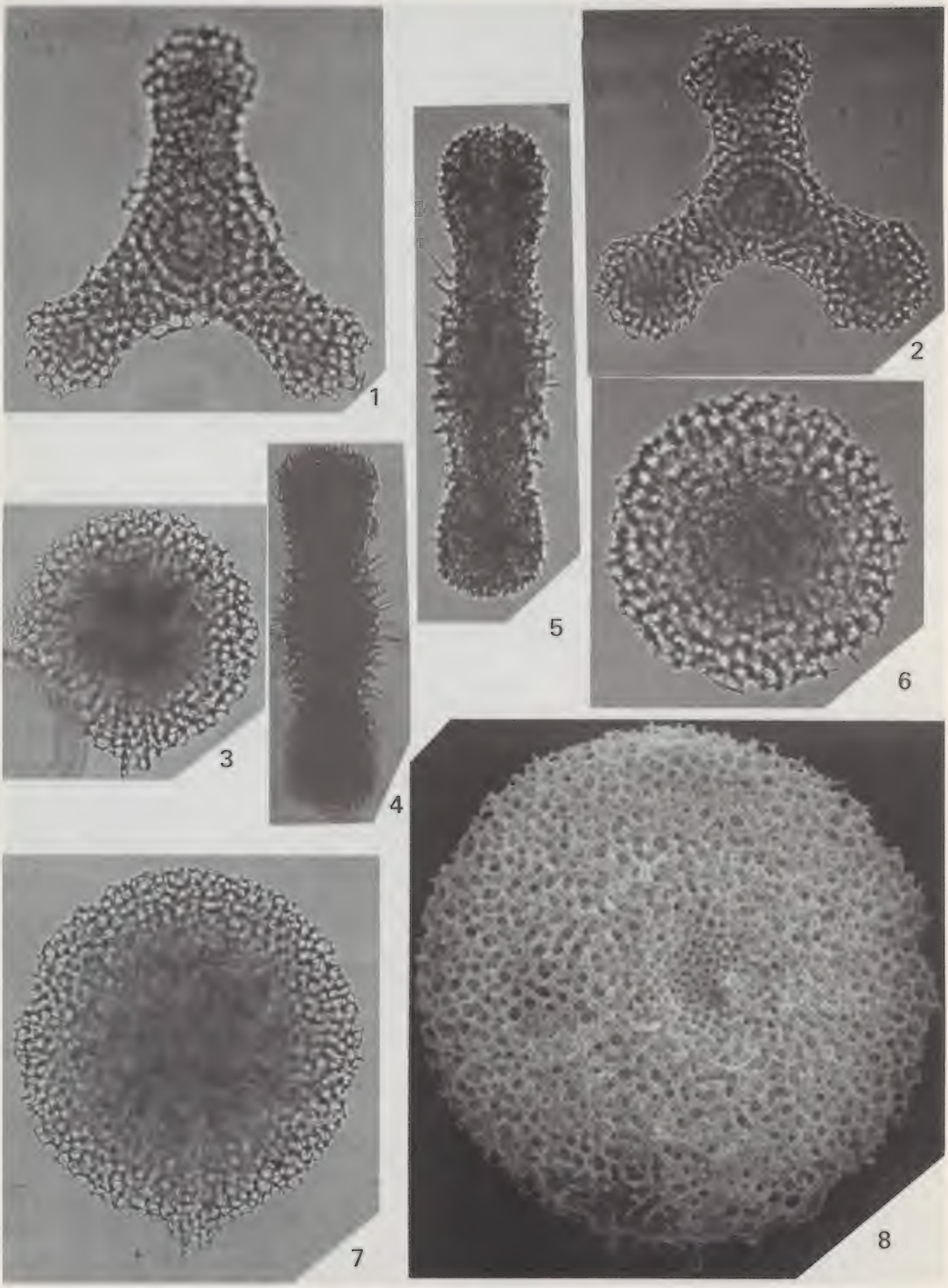


PLATE 2

2, fig. 3 (only), text-fig. 2 (with description); PETRUSHEVSKAYA, 1967, p. 53, fig. 27, 28, I; 29, I; NIGRINI and MOORE, 1979, p. S137, pl. 17, fig. 5; NIGRINI and LOMBARI, 1984, p. S97-S98, pl. 14, fig. 2a-b (with discussion of genus and sp.).

Nigrini and Lombari (1984, p. S98) found this species "common in most of the Miocene sections from both tropical and temperate latitudes." According to Lozano (1974, fig. IV-20), ". . . it is always present under Antarctic waters and generally present under southern subantarctic waters." In general, specimens having thicker and shorter spirals than seen in the holotype of *L. minor* were assigned to *L. nautiloides*.

Genus LITHOCARPIUM Stohr, 1880, emend. Petrushevskaya, 1975

LITHOCARPIUM POLYACANTHA (Campbell and Clark)
Pl. 3, fig. 6

Larnacantha polyacantha CAMPBELL and CLARK, 1944, p. 30, pl. 5, fig. 4-7.
Lithocarpium polyacantha (Campbell and Clark) group. PETRUSHEVSKAYA, 1975, p. 572, pl. 3, fig. 6-8; pl. 29, fig. 6.
Lithocarpium polyacantha (Campbell and Clark). DUMITRICA, 1978, p. 239, pl. 4, fig. 8.

This is a long ranging species group that probably could be subdivided for useful stratigraphic application. Some of the specimens logged from the Sweeny Road section, as well as some included in counts by Campbell and Clark (1944) may be synonymous with several widely distributed species.

Suborder NASSELLARIA Ehrenberg, 1875

Family PLAGONIIDAE Haeckel, 1881, emend. Riedel, 1967b

Numerous small radiolarians have been found in the Monterey Formation and in the overlying beds that belong to *Antarctissa* and related genera. Like the Acanthodesmids, this group requires extensive study of monographic scope before taxonomic and stratigraphic order can be established. *Antarctissa denticulata* and the three unspeciated forms illustrated herein are only a few of the species groups that could be established within the genus. Preliminary observations of material from Sweeny Road, Point Pedernales, Naples Beach, and Newport Bay indicate that there are coeval horizons within the Middle Miocene to Lower Pliocene sequence that could be recognized by definitive study of *Antarctissa* and related genera. Data by Weaver *et al.* (1981, fig. 20 from the Newport Bay section also suggest this conclusion.

Genus ANTARCTISSA Petrushevskaya, 1967

ANTARCTISSA DENTICULATA (Ehrenberg)
Pl. 4, fig. 3

Lithobotrys denticulata EHRENBERG, 1844, p. 203.
Lithopera denticulata (Ehrenberg). EHRENBERG, 1873, pl. 12, fig. 7.
Antarctissa denticulata (Ehrenberg). PETRUSHEVSKAYA, 1967, p. 88, fig. 49, I.

Specimens from near the top (Pliocene) of the section resemble this species recorded by Petrushevskaya from the Antarctic.

PLATE 3

1. *Spongotrochus*(?) *venustum* (Bailey). 66, x320.
2,3. *Xiphospira* sp. cf. *X. circularis* (Clark and Campbell). 69, x320.
4. *Stylodictya validispina* Jørgensen. 73, x400.
5. *Lithelius nautiloides* Popofsky. 72, x320.
6. *Lithocarpium polyacantha* (Campbell and Clark). 48, x400.
7. *Stylodictya validispina* Jørgensen. 42, x400.
8. *Larcospira quadrangula* Haeckel. 65, x320.
9. *Phorticium polycladum* Tan and Tchang. 39, x362.
10. *Lithelius minor* Jørgensen. 45, x320.
11. *Phorticium polycladum* Tan and Tchang. 72, x320.
12. *Lithelius nautiloides* Popofsky. 68, x320.

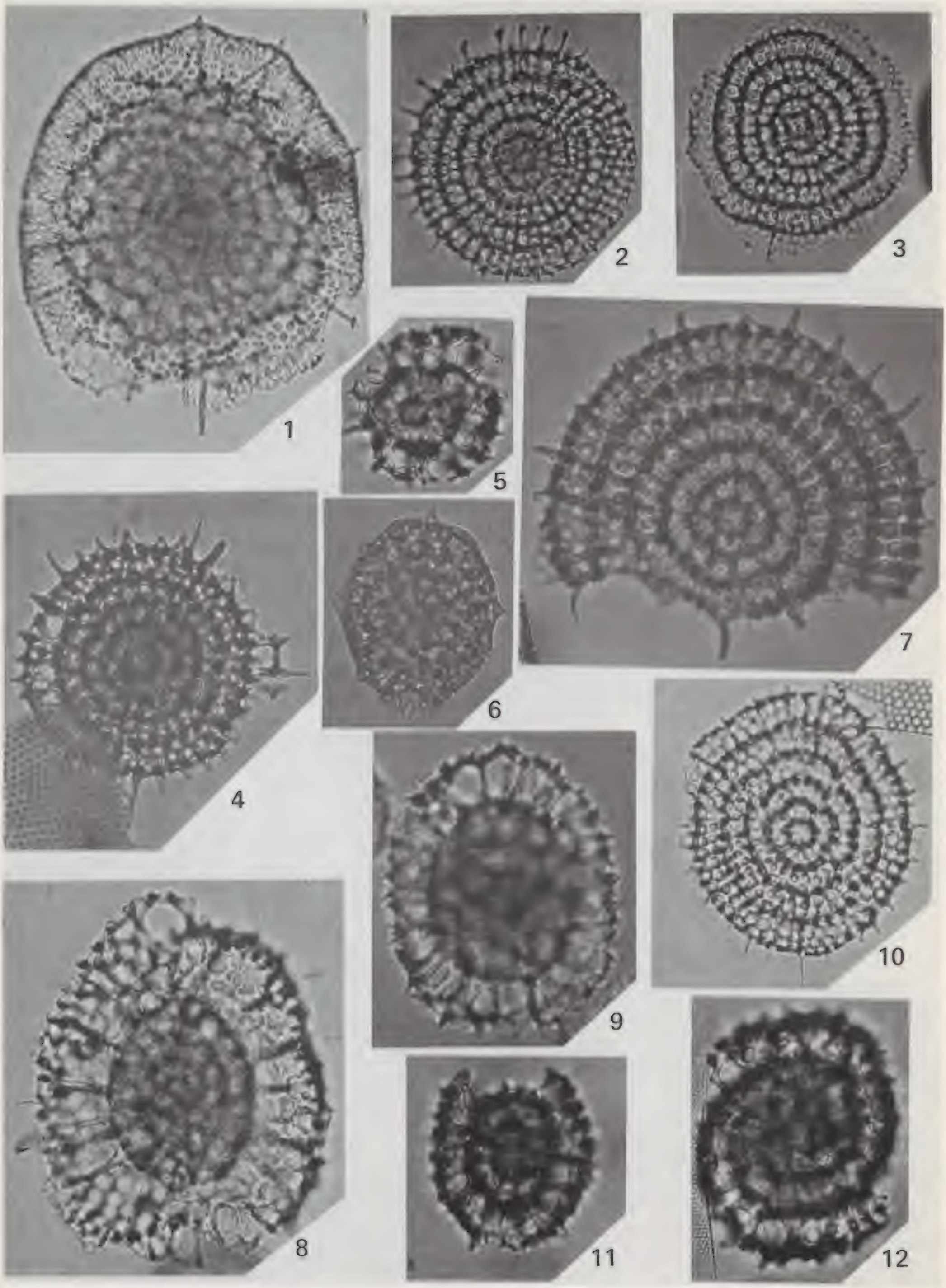


PLATE 3

ANTARCTISSA sp. Group 1
Pl. 4, fig. 1, 2, 4

This group is distinguished by the large size of the thorax relative to the cephalis and by spines that begin as ridges on the proximal portion of the thorax and project beyond the base when not broken off.

ANTARCTISSA sp. Group 2
Pl. 4, fig. 5

This group is distinguished by a large, thorny cephalis that is approximately equal in diameter to the thorax. Spines project beyond the base of the thorax.

ANTARCTISSA sp. Group 3
Pl. 4, fig. 6, 7

This group is distinguished by the hemiellipsoidal shape of the cephalis, a single horn at the tip of the cephalis, and the absence of spines at the distal margin of the shell.

Family TRISSOCYCLIDAE Haeckel, 1881, emend. Goll, 1968
(= Acanthodesmiidae Haeckel, 1862 *in* Riedel, 1971)

Acanthodesmid spp.
Pl. 4, fig. 9-11, 14

Several species belonging to this family were seen throughout the Sweeny Road section, but no attempt was made to record stratigraphic successions or morphologic categories. A comprehensive study of the monographic magnitude and worldwide scope is necessary before the numerous described and unpublished Acanthodesmids can be brought into proper perspective.

Family CARPOCANIIDAE Haeckel, 1881, emend. Riedel, 1967b

Genus et spp. indet.
Pl. 4, fig. 8, 12, 13

This is another family for which monographic treatment is necessary before taxonomic order and stratigraphic successions can be established. Forms assigned to the genera, *Carpocanistrum* and *Carpocanarium*, were logged throughout the Sweeny Road section, but they were not found in high frequency in any of the samples.

Family THEOPERIDAE Haeckel, 1881, emend. Riedel, 1967b

Genus BATHROPYRAMIS Haeckel, 1881

BATHROPYRAMIS WOODRINGI
Campbell and Clark
Pl. 5, fig. 1, 2

Bathropyramis woodringi CAMPBELL and CLARK, 1944, p. 39, pl. 5, fig. 21, 22.
Peripyramis circumtexta Haeckel. CASEY, 1971, pl. 23.1, fig. 11, CASEY *et al.*, 1972, pl. 2, fig. 4.

This long ranging and widely occurring species was found in Early Miocene to Latest Pleistocene at Site 173, Leg 18.

PLATE 4

1. *Antarctissa* sp. Group 1. 43, x375.
2. *Antarctissa* sp. Group 1. 65, x540.
3. *Antarctissa denticulata* (Ehrenberg). 71, x400.
4. *Antarctissa* sp. Group 1. 39, x312.
5. *Antarctissa* sp. Group 2. 69, x400.
6. *Antarctissa* sp. Group 3. 71, x400.
7. *Antarctissa* sp. Group 3. 72, x250.
8. Carpocaniidae, gen. et sp. indet. 39, x320.
9. Acanthodesmid sp. 39, x312.
10. Acanthodesmid sp. 60, x250.
11. Acanthodesmid sp. 39, x250.
12. Carpocaniidae, gen. et sp. indet. 39, x400.
13. Carpocaniidae, gen. et sp. indet. 39, x811, SEM.
14. Acanthodesmid sp. 39, x250.

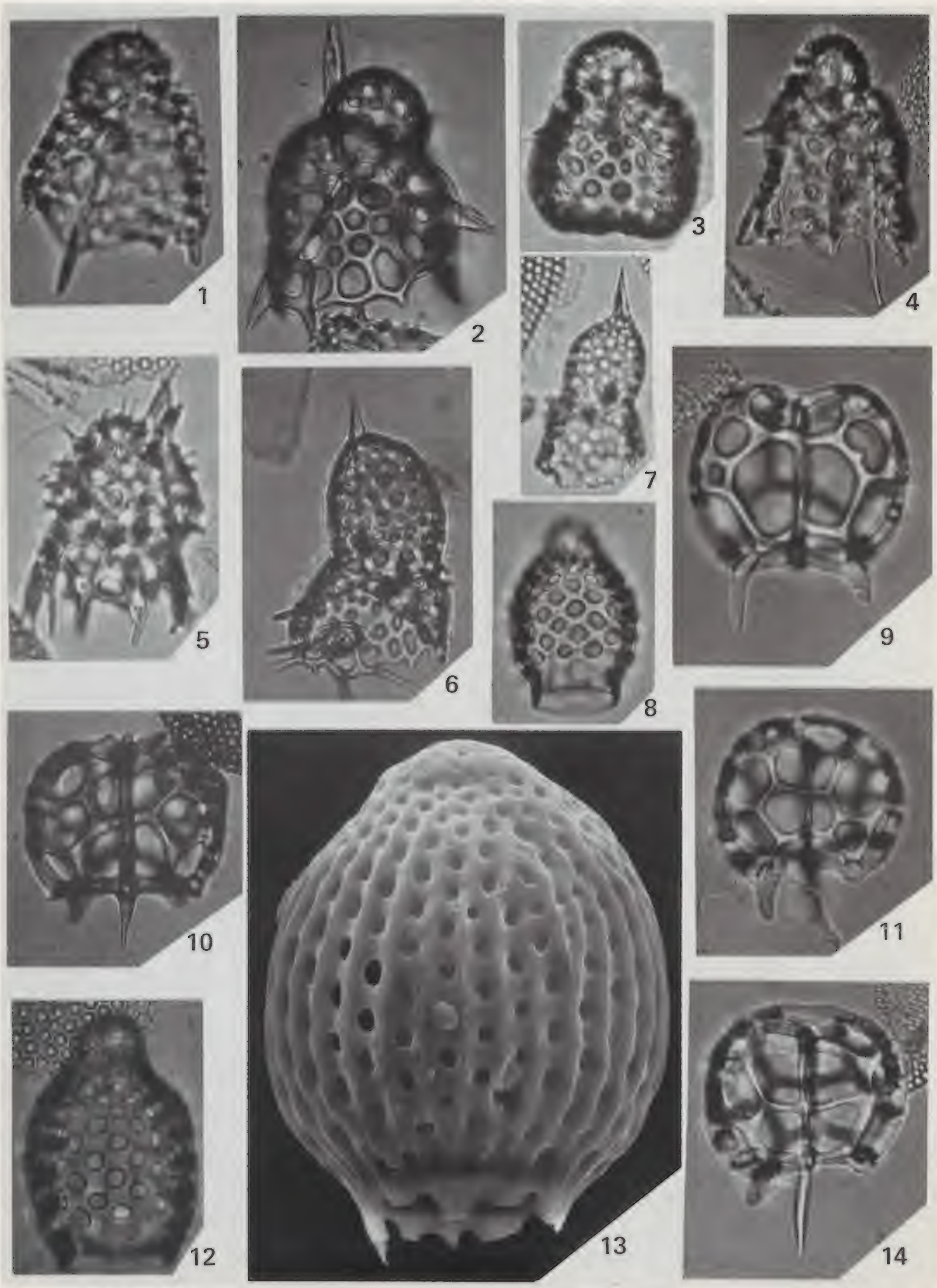


PLATE 4

Genus CLATHROCYCLAS Haeckel, 1887

CLATHROCYCLAS CABRILLOENSIS Campbell and Clark
Pl. 5, fig. 3

Clathrocyclas cabrilloensis CAMPBELL and CLARK, 1944, p. 48, pl. 7, fig. 1-3; KLING, 1973, p. 635, pl. 9, fig. 23-25.

The species may be confined to the Miocene at Site 173 (Kling, 1973, p. 635), but similar forms range higher, and the degree of acceptable variation has not been defined. This species, with two apical horns, was not differentiated from *Conarachnium*(?) *martini* (Campbell and Clark), with a single apical horn, when incomplete specimens were tabulated.

Genus CORNUTELLA Ehrenberg, 1838, emend. Nigrini, 1967

CORNUTELLA PROFUNDA Ehrenberg
Pl. 5, fig. 4

Cornutella clathrata ß *profunda* EHRENBERG, 1854b, p. 241.
Cornutella profunda Ehrenberg. EHRENBERG, 1858, p. 31; NIGRINI, 1967, p. 60, pl. 6, fig. 5a-c (with comprehensive synonymy).
Cornutella paloverdensis CAMPBELL and CLARK, 1944, p. 40, pl. 5, fig. 17, 20, 23, 24, 25.

According to Kling (1973, p. 636), "this species includes numerous intergrading variants, many of which have been described as separate species." He recorded the species from Early Miocene to Late Pleistocene at Site 173.

Genus CYRTOCAPSELLA Haeckel, 1887

CYRTOCAPSELLA CORNUTA (Haeckel)
Pl. 5, fig. 7

Cyrtocapsa (Cyrtocapsella) cornuta HAECKEL, 1887, p. 1513, pl. 78, fig. 9.
Cyrtocapsella cornuta (Haeckel). SANFILIPPO and RIEDEL, 1970, p. 453, pl. 1, fig. 19-20 (with synonymy).

Theyer *et al.* (1978) date the first occurrence of this species at 21.75 Ma and the last occurrence of this species at 11.7 Ma. Rare specimens in the Sweeny Road section have been recycled from Middle or Lower Miocene sediments.

CYRTOCAPSELLA TETRAPERA (Haeckel)
Pl. 6, fig. 8

Cyrtocapsa tetrapera Haeckel, 1887, p. 1512, pl. 78, fig. 5.
Cyrtocapsella tetrapera (Haeckel). SANFILIPPO and RIEDEL, 1970, p. 453, pl. 1, fig. 16-18 (with comprehensive synonymy); NIGRINI and LOMBARI, 1984, p. N109, pl. 23, fig. 5.

Specimens from Sweeny Road material are rare and abraded. The first occurrence of this species has been dated at 21.75 Ma by Theyer *et al.* (1978) and the last occurrence at 12.4-12.7 Ma by Nigrini (Nigrini and Lombari, 1984, p. N110) and more recently at 11.55-11.75 by Nigrini (pers. comm.); therefore, rare occurrences in the Sweeny Road section are considered to have been reworked.

Genus DICTYOPHIMUS Ehrenberg, 1847

DICTYOPHIMUS CRISIAE Ehrenberg
Pl. 5, fig. 6

Dictyophimus crisiae EHRENBERG, 1854b, p. 241; NIGRINI, 1967, p. 66, pl. 6, fig. 7a-b; KLING, 1973, p. 636, pl. 4, fig. 11-15; pl. 10, fig. 18-20.
Pterocorys hirundo Haeckel. CASEY, 1971, pl.

PLATE 5

1. *Bathropyramis woodringi* Campbell and Clark. 42, x320.
2. *Bathropyramis woodringi* Campbell and Clark. 69, x651, SEM.
3. *Clathrocyclas cabrilloensis* Campbell and Clark. 65, x320.
4. *Cornutella profunda* Ehrenberg. 39, x320.
5. *Dictyophimus*(?) sp. 69, x320.
6. *Dictyophimus crisiae* Ehrenberg. 39, x350. SEM.
7. *Cyrtocapsella cornuta* (Haeckel). 10, x320.
8. *Cyrtocapsella tetrapera* (Haeckel). 72, x250.
9,11. *Eucyrtidium* cf. *E. calvertense* Martin. 72, x250.
10. *Eucyrtidium* cf. *E. calvertense* Martin. 66, x250.

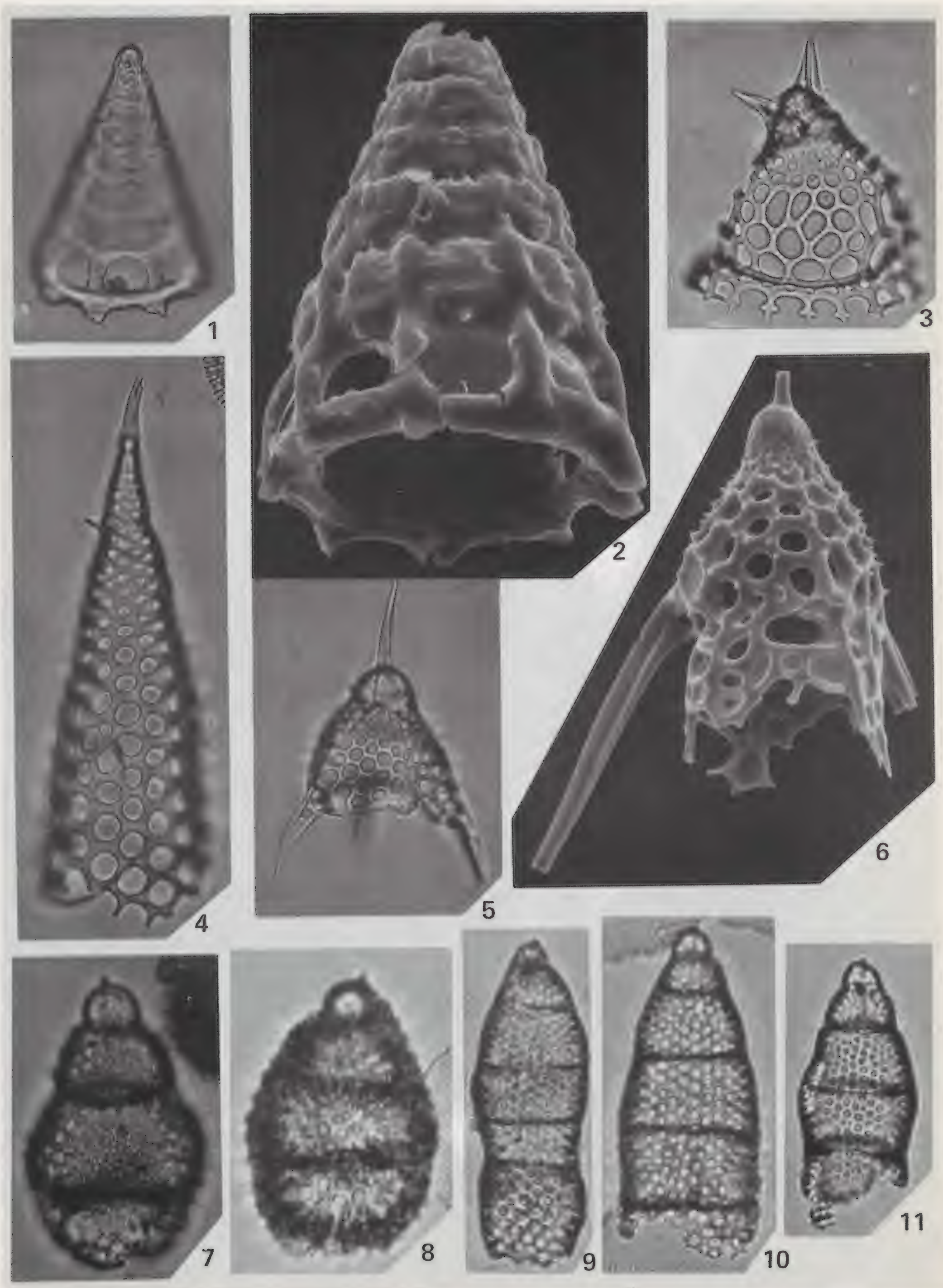


PLATE 5

23.1, fig. 6, 7; Petrushevskaya, 1967 *(partim)*, p. 115, fig. 4, 5.

(?)*Pterocorys hirundo* Haeckel. RIEDEL, 1958, p. 238, pl. 3, fig. 11; pl. 4, fig. 1; PETRUSHEVSDKAYA, 1967 (*partim*), p. 115, fig. 1-3.

Pterocorys splendens CAMPBELL and CLARK, 1944, p. 46, pl. 6, fig. 16, 19, 20; WEAVER *et al.*, 1981, pl. 3, fig. 5, 6.

The range recorded at Site 173 is from the *Dorcadospyris alata* Zone (Miocene) to the *Artostrobium miralestense* Zone (Late Pleistocene). Weaver *et al.* (1981, p. 79, 80) speculated that this form (jr. syn., *Pterocorys splendens)*, along with other species that characterize the *Stichocorys delmontensis* assemblage, including *S. delmontensis, Axoprunum angelinum*, and *Clathrocyclas cabrilloensis*, are "deeper living forms which became more abundant because shallow living radiolarians were generally unsuccessful in competing with diatoms for silica and nutrients at this time."

DICTYOPHIMUS (?) sp.
Pl. 5, fig. 5; Pl. 6, fig. 3, 4.

Forms are referred to here that have approximately twice as many thoracic pores and shorter thoracic spines than *D. crisiae*. Monographic-type research is necessary for these genera if the occasional specimens recovered from the California coastal formations are to be speciated.

Genus EUCYRTIDIUM Ehrenberg, 1847, emend. Nigrini, 1967.

EUCYRTIDIUM sp. cf. E. CALVERTENSE Martin
Pl. 5, fig. 9-11

Eucyrtidium calvertense MARTIN, 1904, p. 450, pl. 130, fig. 5; HAYS, 1965, p. 181, pl. 3, fig. 4; 1970, p. 213, pl. 1, fig. 6; KLING, 1973, p. 636, pl. 4, fig. 16, 18, 19; pl. 11, fig. 1-5.

Definitive work is needed on the species of this genus. Several species occur in the coastal California outcrops. My specimens are assigned tentatively to *E. calvertense*. The range of this species at Site 173 is Early Miocene to Late Pleistocene (Kling, 1973).

Genus LYCHNOCANOMA Haeckel, 1887

LYCHNOCANOMA GRANDE
(Campbell and Clark)
Pl. 6, fig. 1

Lychnocanium grande CAMPBELL and CLARK, 1944, p. 42, pl. 6, fig. 3, 4, 6.

Lychnocanoma grande (Campbell and Clark). KLING, 1973, p. 637, pl. 10, fig. 10-14; WEAVER *et al.*, 1981, pl. 2, fig. 4, 5.

Kling (1973, p. 10, fig. 10-14) logged and illustrated specimens throughout the Miocene section at DSDP Site 173, but he also illustrated specimens from the Pleistocene (Kling, 1973, pl. 4, fig. 9, 10) as *L.* sp. cf. *L. grande* that are similar to the Miocene forms. His Pleistocene specimens appear to have smaller, more closely spaced, and more numerous thoracic pores than seen in his Miocene forms, judging solely by the figures.

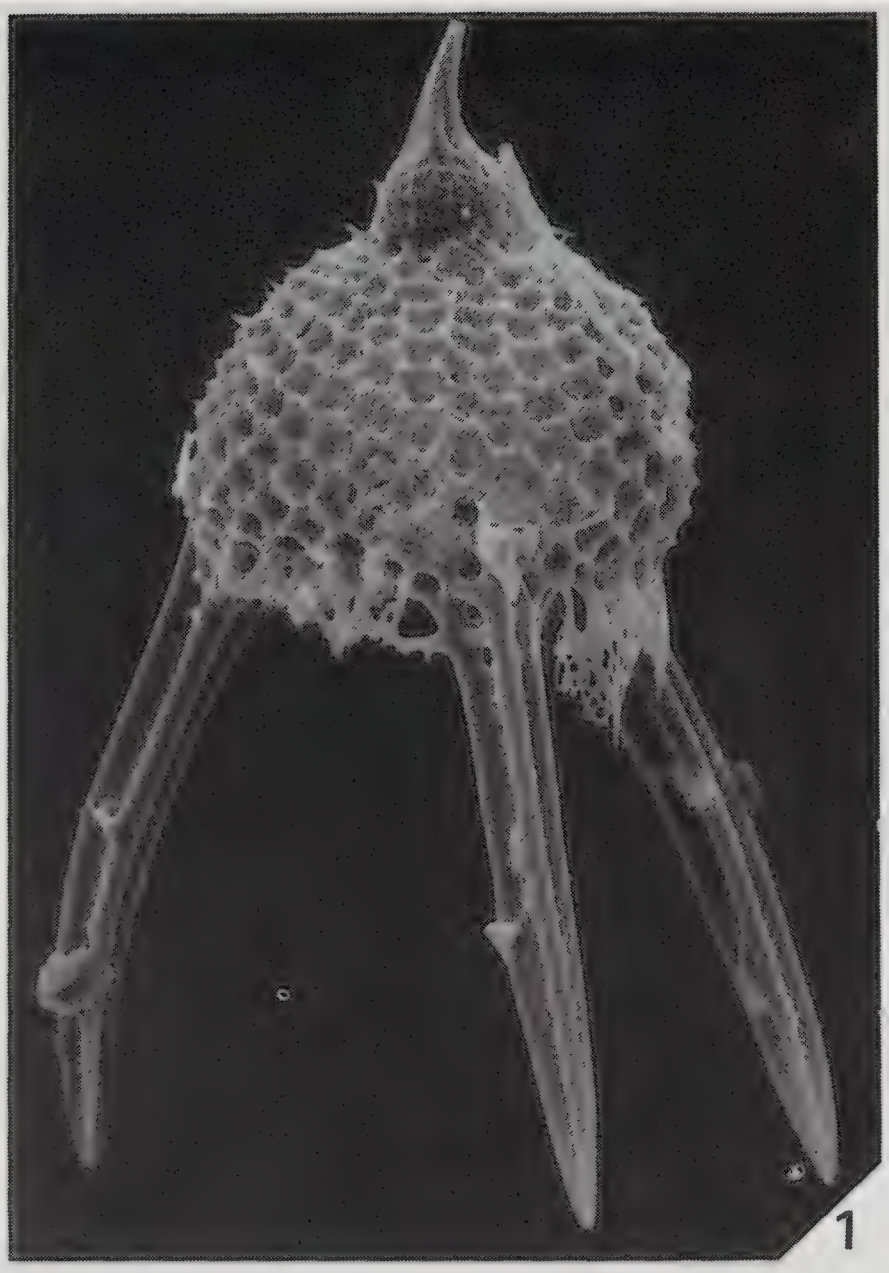
Weaver *et al.* (1981, fig. 2) gave the lowermost occurrence (BM) of *L. grande* at 13.25 Ma (Middle Miocene) and the uppermost occurrence (TM) at 5.75 Ma (Late Miocene) in the section at Newport Bay.

LYCHNOCANOMA sp.
Pl. 6, fig. 2

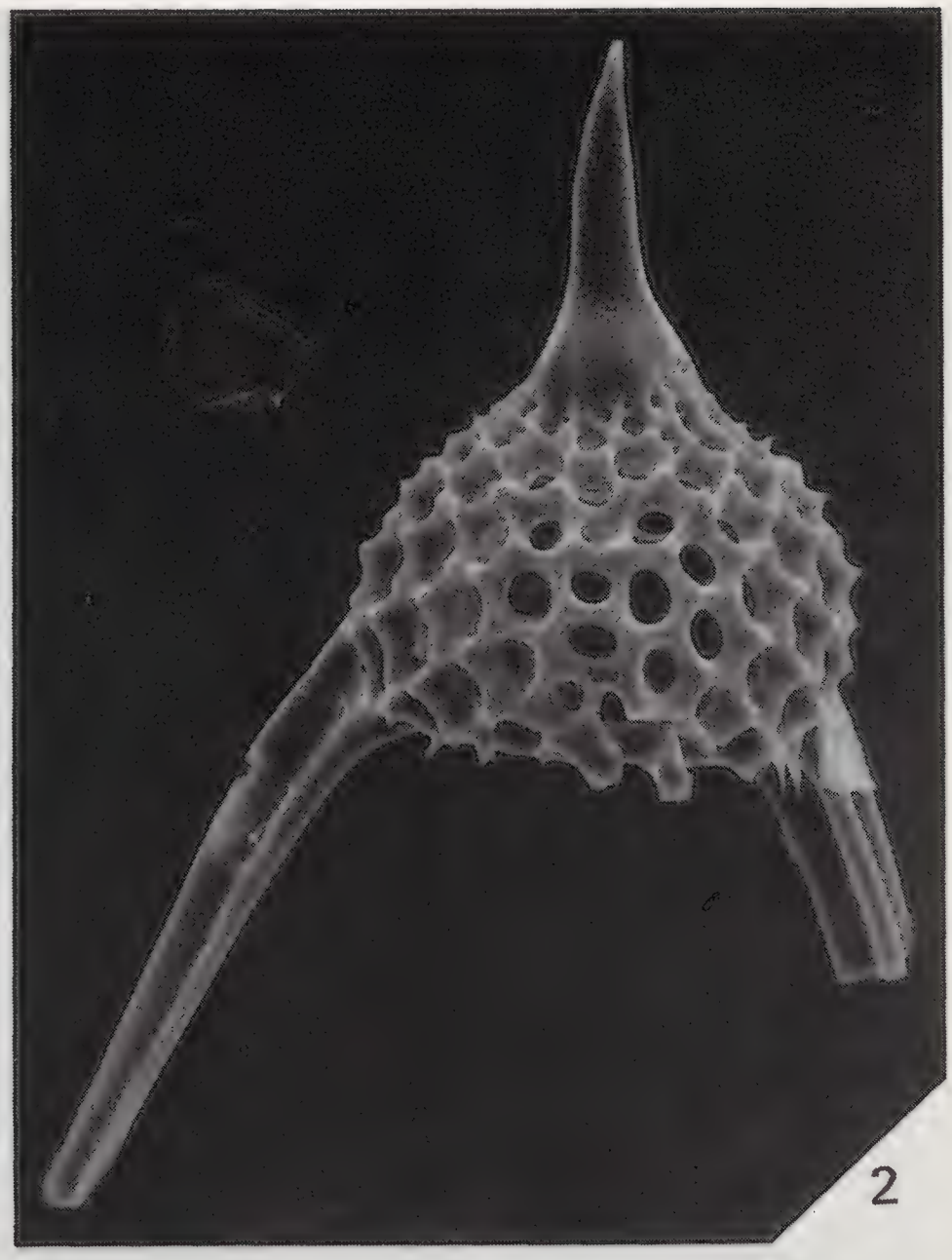
The cephalis in this form is smooth and without pores, having no distinct demarcation between cephalis and the broad, tapering horn, if, indeed, the animal can be said to have a cephalis. The feet are three-bladed and similar to those of *L. grande*, but the thoracic wall structure differs in that *L.* sp. has pores that are twice as large and thorns that are coarser. Further attention to these differences is necessary to determine the precisely relative stratigraphic implications of the members of the genus *Lychnocanoma*.

PLATE 6

1. *Lychnocanoma grande* (Campbell and Clark). 60, x316, SEM.
2. *Lychnocanoma* sp. 39, x340, SEM.
3. *Dictyophimus*(?) sp. 39, x320.
4. *Dictyophimus*(?) sp. 51, x379, SEM.



1



2

3

4

PLATE 6

Genus STICHOCORYS Haeckel, 1881

STICHOCORYS PEREGRINA (Riedel)
Pl. 7, fig. 1-3

Eucyrtidium elongatum peregrinum RIEDEL, 1953, p. 812, pl. 85, fig. 2; Riedel, 1957, p. 94.
Stichocorys peregrina (Riedel). SANFILIPPO and RIEDEL, 1970, p. 451, pl. 1, fig. 10; NIGRINI and LOMBARI, 1984, p. N133, pl. 25, fig. 6 (with data on identification and distribution).

Nigrini and Lombari (1984, p. N134) found this species abundant throughout Late Miocene sections in both tropical and temperate latitudes. They did not find it in any of the Early and Middle Miocene sections.

Theyer *et al.* (1978) dated the first occurrence at 6.4 Ma in the equatorial Pacific. Weaver *et al.* (1981) place the first occurrence at 7.0 Ma in the Newport Bay section (by correlation). The last occurrence is dated by Theyer *et al.* (1978) at 2.4 Ma and more recently at 2.55-2.85 by Nigrini (pers. comm). This is close to the date given by Kling (1973, fig. 1) of 2.8 Ma for Site 173 but at variance with the date (by correlation?) of Weaver *et al.*, 4.4 Ma, for Newport Bay.

The test is resistant to corrosion, a useful feature in diagenetic intervals where diatoms and the more fragile Nassellarians have been destroyed.

Genus STICHOPERA Haeckel, 1881

STICHOPERA PECTINATA Haeckel group
Pl. 7, fig. 4

Stichopera pectinata HAECKEL, 1887, p. 1449, pl. 75, fig. 11; Kling, 1973, p. 638, pl. 3, fig. 25-27; pl. 10, fig. 1-5.
Cyrtopera laguncula HAECKEL, 1887, p. 1451, pl. 75, fig. 10.

The species group is rare in the Monterey Formation. It ranges from Early Miocene to Late Pleistocene at Site 173.

Genus THEOCALYPTRA Haeckel, 1887

THEOCALYPTRA BICORNIS (Popofsky)
Pl. 7, fig. 6, 8

Pterocorys bicornis POPOFSKY, 1908, p. 228, pl. 34, fig. 7, 8.
Theocalyptra bicornis (Popofsky). RIEDEL, 1958, p. 240, pl. 4, fig. 4; PETRUSHEVSKAYA, 1967, p. 126, pl. 71, fig. 2-9; pl. 72, fig. 1-4; NIGRINI and MOORE, 1979, p. N53, pl. 24, fig. 1.

Definitive study is needed for this group and should include species referred to *Theocalyptra* and *Clathrocyclas*. Forms with a single horn are tentatively included here, as well as specimens bearing two well-developed horns. Other differences are not apparent.

Genus THEOCORYS Haeckel, 1881

THEOCORYS sp. cf. T. REDONDOENSIS (Campbell and Clark)
Pl. 7, fig. 5

Theocyrtis redondoensis CAMPBELL and CLARK, 1944, p. 49, pl. 7, fig. 4; CASEY *et al.*, 1972, pl. 2, fig. 3.
Theocorys redondoensis (Campbell and Clark). KLING, 1973, p. 638, pl. 11, fig. 26-28; NIGRINI and LOMBARI, 1984, p. N143, pl. 26, fig. 4 (descriptive notes and distribution).

At Site 173, *T. redondoensis* ranges from the *Dorcadospyris alata* Zone (Early Miocene) to the *Stichocorys peregrina* Zone (Late Miocene). It is rare in the Sweeny Road section. The illustrated specimen bears traces (remnants?) of thoracic spines and, accordingly, is not typical of the species. Most of our specimens have spines, whereas specimens without spines are rare, and we wonder if the species should be emended to include forms with spines.

PLATE 7

1-3. *Stichocorys peregrina* (Riedel). 1, 39, x384, SEM; 2, 69, x400; 3, 31, x320.
4. *Stichopera pectinata* Haeckel group. 39, x400.
5. *Theocorys* cf. *T. redondoensis* (Campbell and Clark). 60, x320, SEM.
6,8. *Theocalyptra bicornis* (Popofsky). 6, 72, x320; 8, 69, x320.
7,9. *Theocorys* sp. 7, 66, x250; 9, 51, x505, SEM.

1

2

3

4

6

7

5

8

9

PLATE 7

THEOCORYS sp.
Pl. 7, fig. 7, 9

This group is designated for those specimens with two series of long, well-developed thoracic spines. See *T.* sp. cf. *T. redondoensis*.

Family PTEROCORYTHIDAE Haeckel, 1881, emend. Riedel, 1967b emend. Moore, 1972

Genus ANTHOCYRTIDIUM Haeckel, 1881

ANTHOCYRTIDIUM OPHIRENSE (Ehrenberg)
Pl. 8, fig. 1

Anthocyrtis ophirensis EHRENBERG, 1872, p. 301; Haeckel, 1887, p. 1270.
Anthocyrtidium ophirense (Ehrenberg). NIGRINI, 1967, p. 56, pl. 6, fig. 3 (with synonymy); NIGRINI and MOORE, 1979, p. N67, pl. 25, fig. 1.

Pores are larger in specimens from the Monterey Formation than illustrated for *A. ehrenbergi ehrenbergi* (Stohr) or *A. ophirensis* (Ehrenberg).

Genus LAMPROCYRTIS Kling, 1973

LAMPROCYRTIS(?) HANNAI
(Campbell and Clark)
Pl. 8, fig. 2-5

Calocyclas hannai CAMPBELL and CLARK, 1944, p. 48, pl. 6, fig. 21-22; CASEY *et al.*, 1972, pl. 2, fig. 19.
(?)*Calcocyclas margatensis* CAMPBELL and CLARK, 1944, p. 47, pl. 6, fig. 17-18; CASEY *et al.*, 1972, pl. 3, fig. 10-22.
Lamprocyrtis(?) *hannai* (Campbell and Clark). KLING, 1973, p. 638, pl. 5, fig. 12-14; pl. 12, fig. 10-14; NIGRINI and MOORE, 1979, p. N83, pl. 25, fig. 8.

This species has been found throughout Miocene sections from both tropical and temperate latitudes (Nigrini and Lombari, 1984, p. N166). Kling (1973, pl. 5, fig. 12-14; pl. 12, fig. 10-14) figured specimens from the *Calocycletta costata* Zone (Early Miocene) to the *Artostrobium miralestense* Zone (Late Pleistocene) for DSDP Site 173. It is also present in Holocene samples (Nigrini and Moore, 1979, p. N84), but to my knowledge, neither modern nor fossil occurrences are known outside the Pacific Ocean region. Kling (1973, p. 638), proposed *L.*(?) *hannai* as a likely ancestor of the Piocene-Pleistocene *L. heteroporos*.

LAMPROCYRTIS HETEROPOROS (Hays)
Pl. 8, fig. 6-9

Lamprocyclas heteroporos HAYS, 1965, p. 179, pl. 3, fig. 1; KLING, 1971, p. 1088, pl. 1, fig. 1.
Lamprocyclas heteroporos? Hays. HAYS, 1970, p. 214, pl. 1, fig. 3.
Lamprocyrtis heteroporos (Hays). KLING, 1973, p. 618, 639, pl. 5, fig. 19-21; pl. 15, fig. 6; WEAVER *et al.*, 1981, p. 80, 81, pl. 5, fig. 1.

This species is characteristic of the upper part of the Sweeny Road section (Pliocene). It is also well represented in the Pliocene beds at DSDP Site 173 and Newport Bay. The following quotations are worthy of note in regard to these localities and other occurrences of *L. heteroporos* in the Pacific Coast region:

"Pliocene. The base of the Pliocene in the Pacific Coast region is tentatively taken as the earliest appearance of *Lamprocyrtis heteroporos* (=*Lamprocyclas heteroporos*). This level occurs near the top of the Capistrano formation at Newport Bay, California (unpublished data), at a level approximating the Miocene-Pliocene boundary based on foraminifera" (Ingle, 1967; 1972). At Malaga Cove, California, it occurs in the Malaga Mudstone with the Delmontian stage according to Casey *et al.* (1972).

"At Site 173, *Lamprocyrtis heteroporos* ranges above the first appearance of *Eucyrtidium matuyamai*, its extinction level in the North Pacific. Therefore, the first evolutionary appearance of *E. matuyamai* is taken as the top of the *L. heteroporos* Zone and base of the overlying *E. matuyamai* Zone. This level appears

PLATE 8

1. *Anthocyrtidium ophirense* Ehrenberg. 43, x320.
2-5. *Lamprocyrtis(?) hannai* (Campbell and Clark). 2, 64, x334, SEM; 3-4, 64, x375, A specimen at two different levels of focus; 5, 60, x450, SEM.
6-9. *Lamprocyrtis heteroporos* (Hays). 6, 71, x320; 7, 60, x250; 8, 69, x460, SEM; 9, 72, x250.

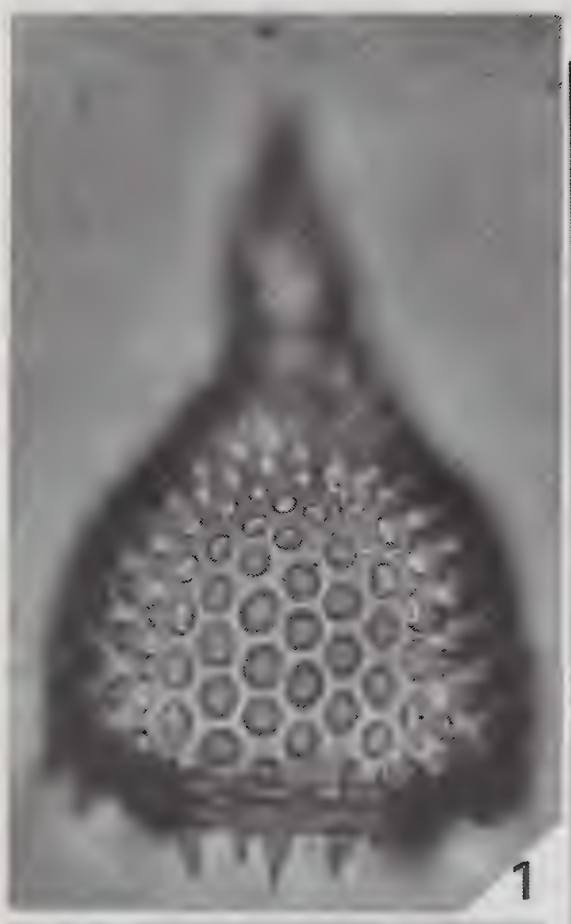


PLATE 8

consistent with the first appearance of *E. matuyamai* in the North Pacific and agrees more closely with estimates of the Pliocene-Pleistocene boundary based on other microfossils at Site 173 than does the top of *Lamprocyrtis heteroporos*. Radiometric-paleomagnetic dates are assumed to be the same as in the Gulf of Alaska, although comparison with the paleomagnetic results from this site (Heinrichs, this volume) may reveal some disagreement due to differing species ranges." (Kling, 1973, p. 618).

"The *Lamprocyrtis heteroporos* assemblage is very similar to the *Stichocorys peregrina* assemblage with the exception that *Lamprocyrtis heteroporos* is present. Just as in the upper portion of the range of the *Stichocorys peregrina* assemblage, warm water radiolarians are nearly absent. When they do occur, percentages never exceed 1%. These warm water radiolarians usually consist of specimens of *Eucyrtidium acuminatum, Lamprocyclas maritalis*, or *Theoconus zancleus*.

"The *Lamprocyrtis heteroporos* assemblage, at least up to 4.7 m.y. B.P., appears to be a continuation of the cool temperate to transitional California Current fauna of the Late Miocene *Stichocorys peregrina* assemblage.

"At approximately 4.7 m.y. B.P., prior to the base of Barron's (in press) *Thalassiosira oestrupii* Zone, we observe the widespread occurrence of the *Lamprocyrtis heteroporos* acme. It is not uncommon to find *Lamprocyrtis heteroporos* representing up to 15% of the total fauna in any one sample. The exact significance of this acme as it may relate to paleoceanographic conditions is uncertain. However, at Centerville Beach, this acme is associated with the occurrence of tropical to warm temperate diatoms in the uppermost Pullen Formation. This suggests that this acme may be somehow related to the global warming that commenced at about this time which is well documented in the literature (Ingle, 1967; Stainforth *et al.*, 1975)" (Weaver *et al.*, 1981, p. 80-81).

Our studies of the section exposed in the cliffs at Newport back bay confirm the earliest occurrence of *L. heteroporos* as reported by Weaver *et al.* (1981, fig. 2, see Figure 7). This occurrence approximates their placement of the Miocene-Pliocene boundary.

Family ARTOSTROBIIDAE Riedel, 1967b, emend. Foreman, 1973

Genus BOTRYOSTROBUS Haeckel, 1887, emend. Nigrini, 1977

BOSTRYOSTROBUS AURITUS/AUSTRALIS (Ehrenberg) group
Pl. 9, fig. 1, 2, 5

Botryostrobus auritus/australis (Ehrenberg) group. NIGRINI, 1977, p. 246, pl. 1, fig. 2-5 (synonymy).

This group has been recorded from the *Diartus petterssoni* Zone to Holocene (Nigrini, 1977, p. 248).

BOTRYOSTROBUS BRAMLETTEI (Campbell and Clark)
Pl. 9, fig. 3, 4, 8

Lithomitra bramlettei CAMPBELL and CLARK, 1944, p. 53, pl. 7, fig. 10-14.
Botryostrobus bramlettei (Campbell and Clark). NIGRINI, 1977, p. 248, pl. 1, fig. 7-8 (synonymy); NIGRINI and LOMBARI, 1984, p. N175, pl. 31, fig. 2a-c.

Nigrini (1977, p. 249) recorded this species from the *Diartus petterssoni* Zone (Middle Miocene) to the *Stichocorys peregrina* Zone (Upper Miocene), but we found it in Sample 66, Sweeny Road, and Kling

PLATE 9

1,2,5. *Botryostrobus auritus/australis* (Ehrenberg) group. 1, 71, x320; 2, 39, x601, SEM; 5, 48, x320.
3,4,8. *Botryostrobus bramlettei* (Campbell and Clark). 3, 39, x568, SEM; 4, 72, +28 microns, x400; 8, 39, x312.
6,7,9. *Phormostichoartus fistula* Nigrini. 6,7, 73, x400; 9, 70, x320.
10. *Botryostrobus* cf. *B. miralestensis* (Campbell and Clark). 39, x526, SEM.
11. *Phormostichoartus corbula* (Harting). 44, x320.
12-14. *Phormostichoartus* sp. 12, 72, x400; 13, 39, +28 microns, x480; 14, 43, x400.

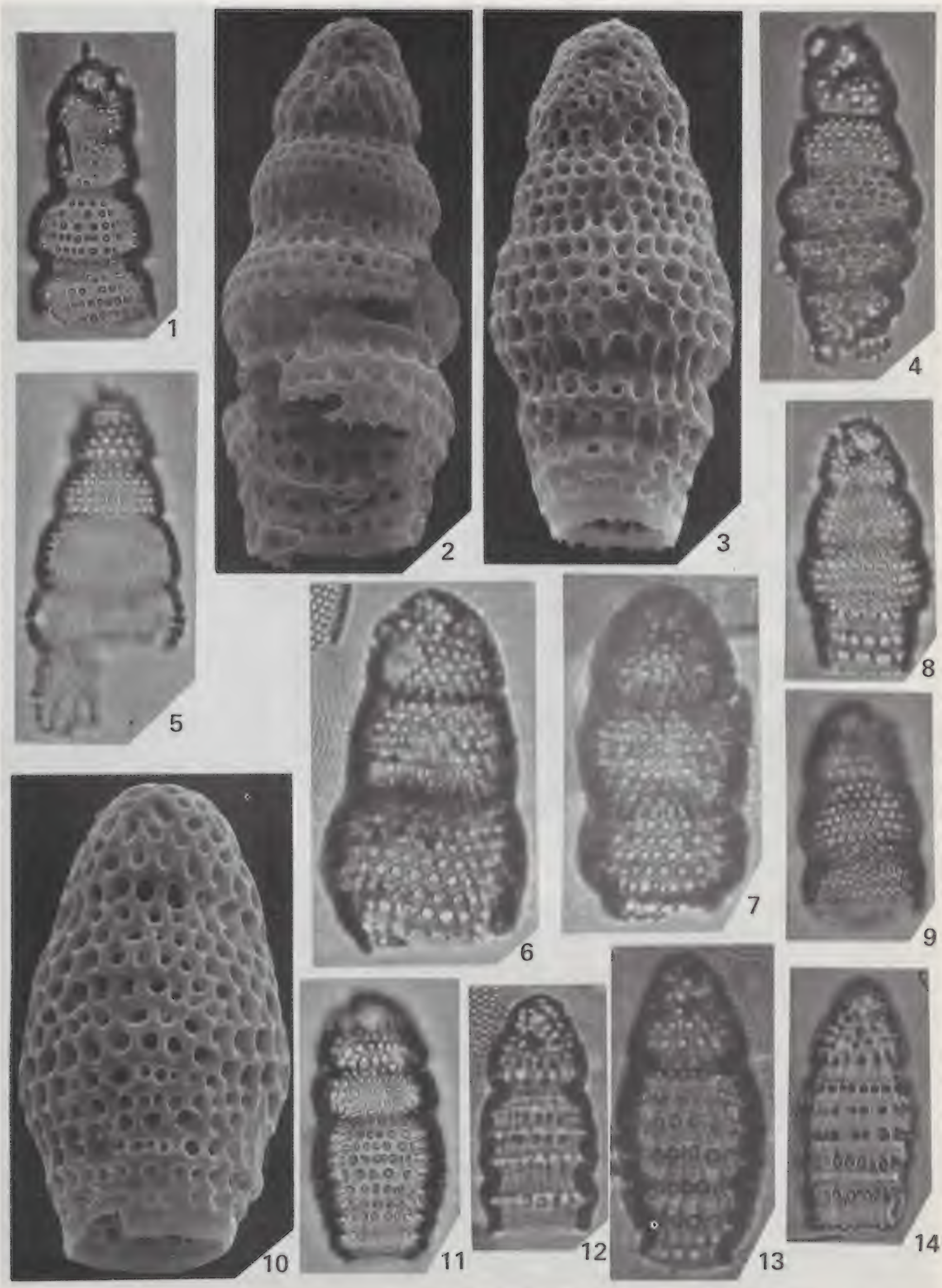


PLATE 9

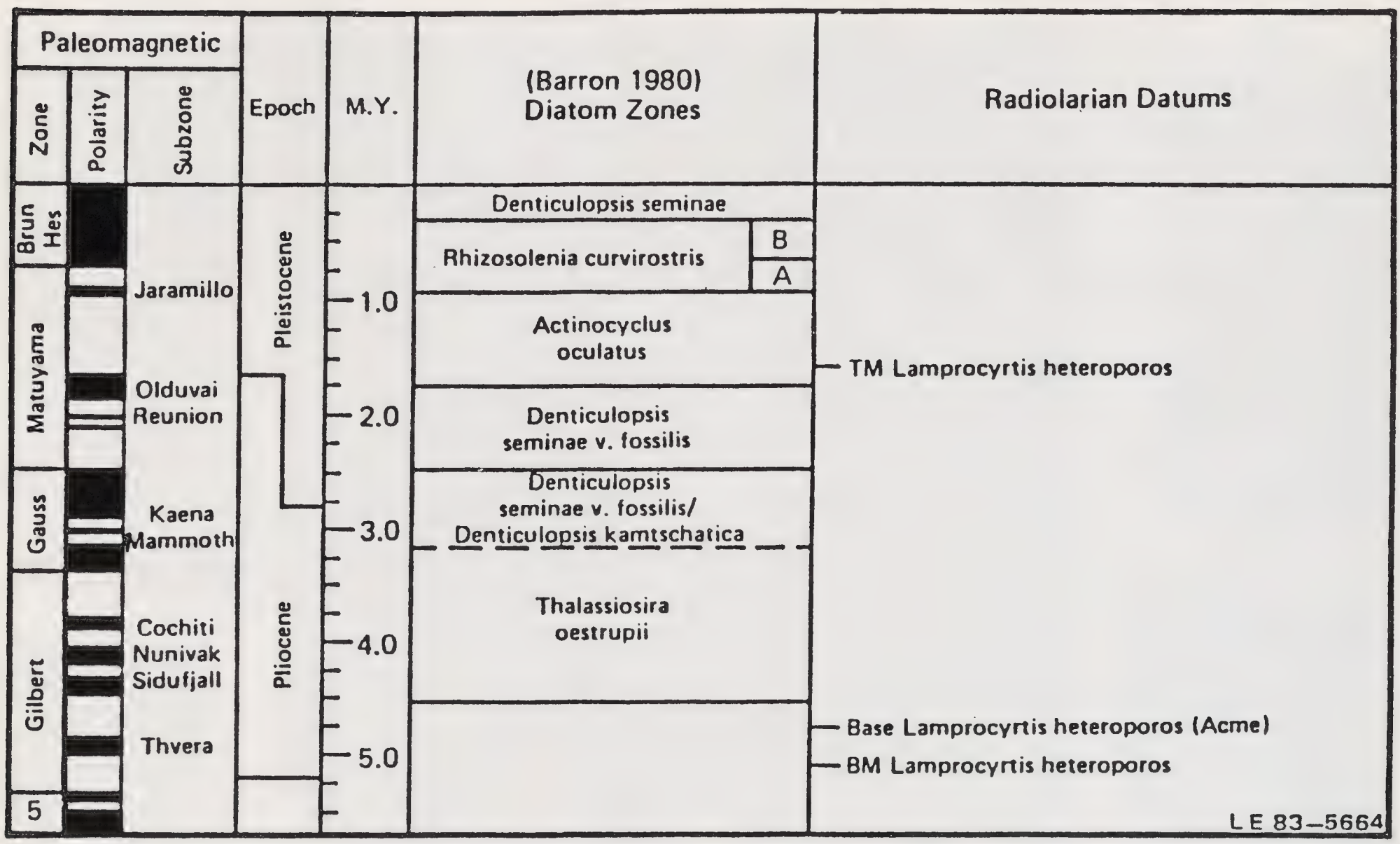


Figure 7. *Lamprocyrtis heteroporos* in the section at Newport Bay (After Weaver *et al.*, 1981, portion of fig. 2).

(1973, pl. 5, 12) may have logged the species well above the Miocene at Site 173 as *Artostrobium auritum* (Ehrenberg). This species lived into the Pliocene, if these latter occurrences are, indeed, *B. bramlettei* and if they are not the result of redeposition.

BOTRYOSTROBUS cf. B. MIRALESTENSIS
(Campbell and Clark)
Pl. 9, fig. 10

Botryostrobus miralestensis CAMPBELL and CLARK, 1977, p. 249, pl. 1, fig. 9 (synonymy).

A diverse *Botryostrobus* fauna in Sample 39 contains rare specimens that are tentatively referred to the taxon of Campbell and Clark. The form was not found elsewhere in the Sweeny Road section. *Artostrobium miralestense* was logged by Kling (1973) from Early Miocene to latest Pleistocene at Site 173, but Nigrini (1977, p. 249, pl. 1, fig. 9) figured a similar form as *Botryostrobus miralestensis* (Campbell and Clark) and recorded it from Lower Miocene to Middle Miocene only.

Genus PHORMOSTICHOARTUS
Campbell, 1951, emend. Nigrini, 1977

PHORMOSTICHOARTUS CORBULA (Harting)
Pl. 9, fig. 11

Phormostichoartus corbula (Harting). NIGRINI, 1977, p. 252, pl. 1, fig. 10 (with synonymy).

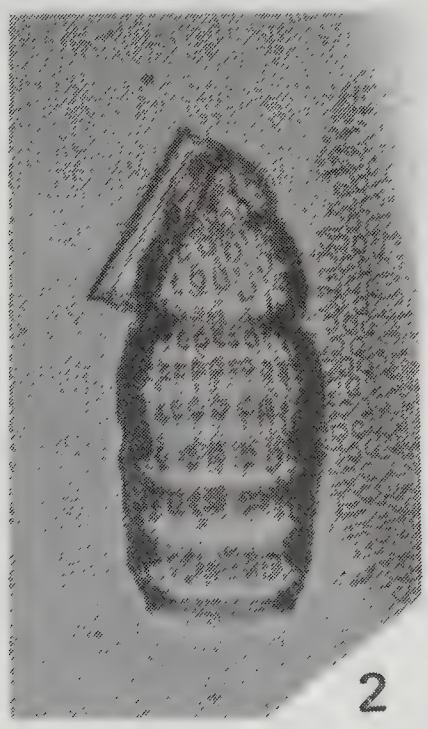
This species is "rare to few from the *Dorcadospyris alata* Zone (Middle Miocene) to Recent," according to Nigrini (1977, p. 252).

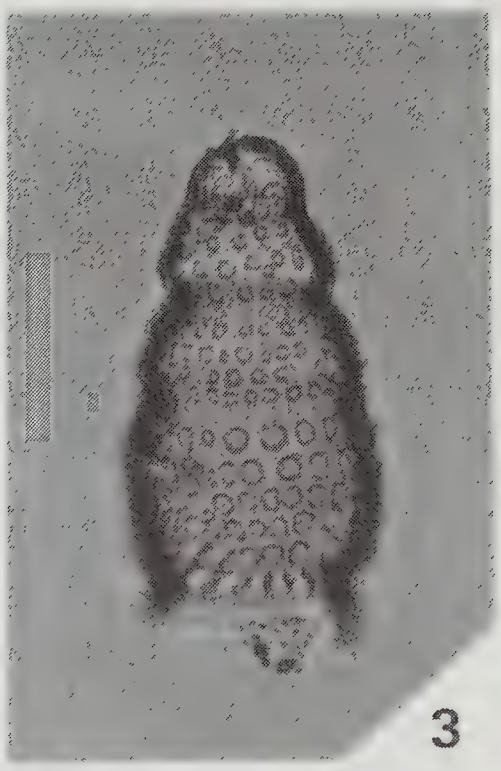
PHORMOSTICHOARTUS FISTULA Nigrini
Pl. 9, fig. 6, 7, 9

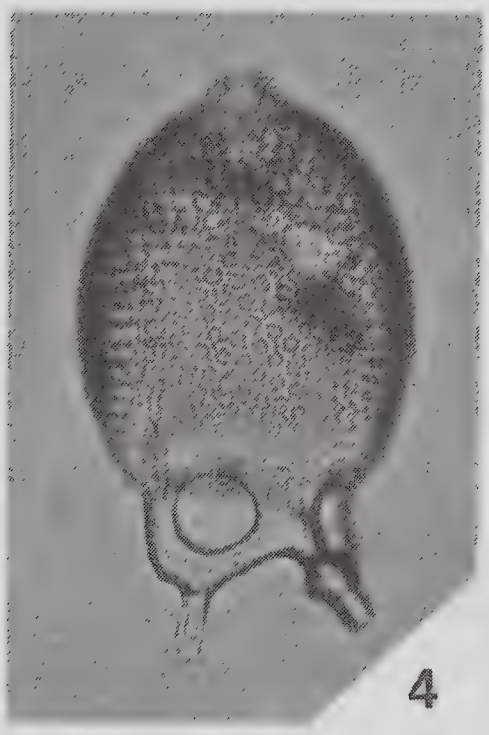
Phormostichoartus fistula NIGRINI, 1977, p. 253, pl. 1, fig. 11-13 (with synonymy); NIG-

PLATE 10

1. *Siphocampe arachnea* (Ehrenberg). 42, x320.
2. *Siphocampe nodosaria* (Haeckel). 39, x320.
3. ?*Spirocyrtis subscalaris* Nigrini. 39, x320.
4,5. *Challengeron diodon* Haeckel. 4, 54, x320; 5, 60, x320.







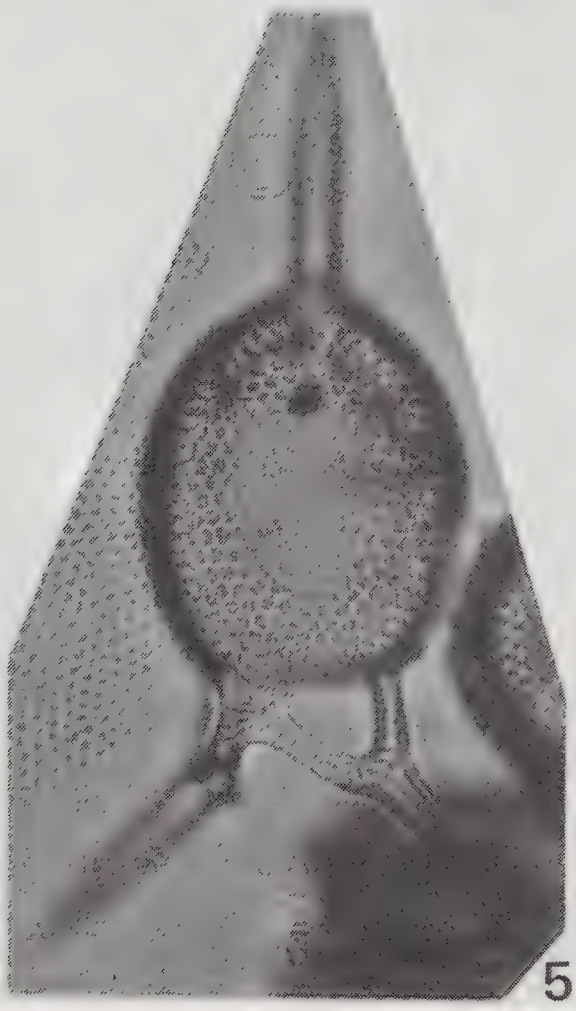


PLATE 10

RINI and LOMBARI, 1984, pl. 31, fig. 6a-c.

Nigrini (1977a, p. 253) has recorded this species as rare from the *Thyrsocyrtis bromia* Zone (Upper Eocene) to the *Spongaster pentas* Zone (Pliocene).

PHORMOSTICHOARTUS sp.
Pl. 9, fig. 12-14

Specimens of this group are of such low frequency that species concepts are difficult to visualize. Forms illustrated here may belong to several species, especially the *Siphocampe lineata* group, according to Nigrini, 1977 (personal communication).

Genus SIPHOCAMPE Haeckel, 1881, emend. Nigrini, 1977

SIPHOCAMPE ARACHNEA (Ehrenberg)
Pl. 10, fig. 1

Siphocampe arachnea (Ehrenberg) group. NIGRINI, 1977, p. 255, pl. 3, fig. 7-8 (with synonymy).

This group has been recorded from the *Stichocorys wolffii* Zone (Lower Miocene) to Holocene (Nigrini, 1977, p. 255).

SIPHOCAMPE NODOSARIA (Haeckel)
Pl. 10, fig. 2

Siphocampe nodosaria (Haeckel). NIGRINI, 1977, p. 256, pl. 3, fig. 11 (with synonymy).

This species is rare from the *Thyrsocyrtis triacantha* Zone (Middle Eocene) to Holocene (Nigrini, 1977, p. N192).

Genus SPIROCYRTIS Haeckel, 1881, emend. Nigrini, 1977

?SPIROCYRTIS SUBSCALARIS Nigrini
Pl. 10, fig. 3

Lithamphora furcaspiculata POPOFSKY, 1913, p. 408, text-fig. 132 (*partim*).

Spirocyrtis sp. aff. *S. scalaris* Haeckel. RIEDEL and SANFILIPPO, 1971, pl. 1G, fig. 19, 20, 22 (*partim*).

Spirocyrtis ex. gr. *scalaris* Haeckel. DUMITRICA, 1973, p. 840, pl. 15, pl. 9.

Artostrobiid cf. *Artostrobium rhinoceros* SANFILIPPO and RIEDEL, 1974, pl. 4, fig. 10 (*partim*).

Spirocyrtis subscalaris NIGRINI, 1977, p. 259, pl. 3, fig. 1, 2.

A single specimen from the Artostrobiidae-rich bed 39 is provisionally referred to this species. The duck-billed vertical tube is not clearly visible.

Order PHAEODARIA Haeckel, 1879
Suborder PHAEOGROMIA Haeckel, 1879
Family CHALLENGERIIDAE Murray, 1876

Genus CHALLENGERON Haeckel, 1887

CHALLENGERON DIODON Haeckel
Pl. 10, fig. 4, 5

Challengeron diodon HAECKEL, 1887, p. 1654, pl. 99, fig. 6.

Rare specimens are conspecific with the holotype from "the southeastern Pacific, west of Valparaiso, *Challenger* Station 298, Lat. 40°3′S, Long. 132°58′W, 2600 fathoms." Haeckel characterized the shell wall of this genus as "diatomaceous," because of the similarity to shells of the Diatomaceae, and he noted that members of this phaeodarian family are "for the most part, inhabitants of great depth." To my knowledge, this is the first documentation of both the genus and the species in the Pliocene, unless Haeckel's type level is of that age rather than Holocene. The Sweeny Road occurrences are the first documentation of the order in the coastal California formations.

Dumitrica (1973c, p. 755) considered the challengeriids as "incontestably the most frequent phaeodarians in sediments, if not numerically, at least specifically." He recorded almost all suborders and families of Phaeodaria in cores of Leg 21 of the DSDP. This leg comprised an almost continuous radiolarian sequence from Oligocene to Quaternary, enabling him to trace the origin of some living taxa "to various levels of the Quaternary, Pliocene, or Miocene."

Haeckel (1887, p. 1653) attributed the genus to John Murray ("1879, in *litteris* et *schedulis*"), which was never validated by publication.

Check Chart I
Sweeny Road Radiolarians
Alphabetized

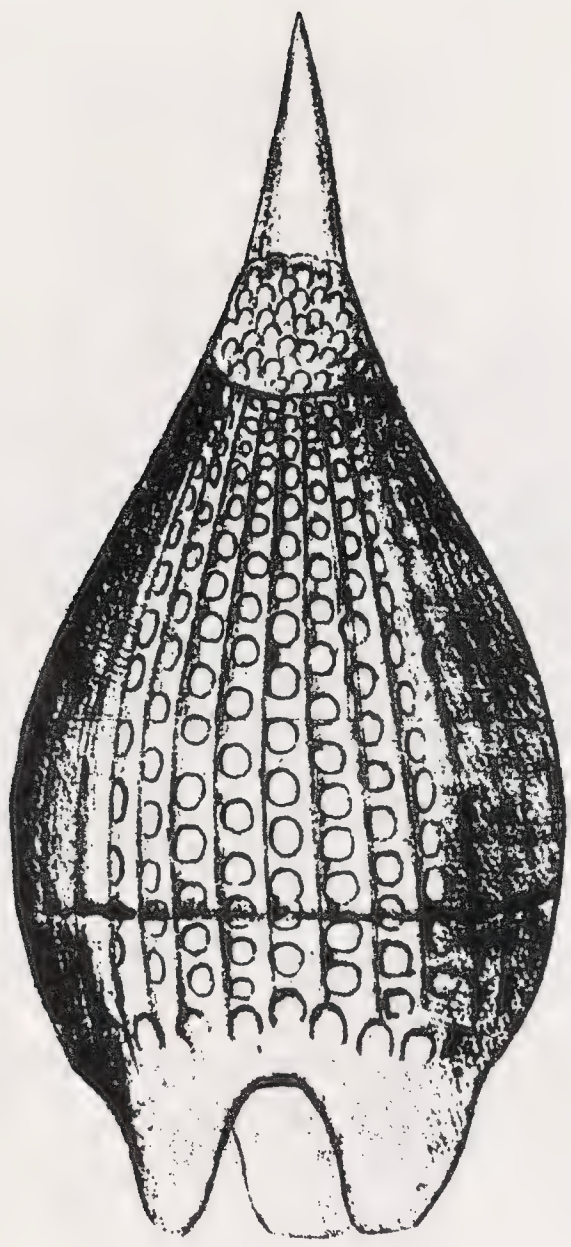
| Sample Number / Taxa | ACANTHODESMID SPP. | ACTINOMMA SPP. | ANTARCTISSA DENTICULATA | ANTARCTISSA SP. GP. 1 | ANTARCTISSA SP. GP. 2 | ANTARCTISSA SP. GP. 3 | ANTHOCYRTIDIUM OPHIRENSE | AXOPRUNUM ANGELINUM | BATHROPYRAMIS WOODRINGI | BOTRYOSTROBUS AURITUS/AUSTRALIS GROUP | BOTRYOSTROBUS BRAMLETTEI | BOTRYOSTROBUS SP. CF. B. MIRALESTENSIS | CARPOCANIIDAE, GEN. ET SP. INDET. | CHALLENGERON DIODON | CIRCODISCUS MICROPORUS | CLATHROCYCLAS CABRILLOENSIS | CORNUTELLA PROFUNDA | CROMYDRUPPOCARPUS ESTERAE | CYRTOCAPSELLA CORNUTA | CYRTOCAPSELLA TETRAPERA | DICTYOPHIMUS CRISIAE | DICTYOPHIMUS(?) SP. | EUCYRTIDIUM SP. CF. E. CALVERTENSE | HEXACONTIUM SPP. | HYMENIASTRUM SPP. | LAMPROCYRTIS HETEROPOROS | LAMPROCYRTIS(?) HANNAI | LARCOSPIRA QUADRANGULA | LITHATRACTUS TIMMSI | LITHELIUS MINOR | LITHELIUS NAUTILOIDES | LITHOCARPIUM POLYACANTHA | LYCHNOCANOMA GRANDE | LYCHNOCANOMA SP. | PHORMOSTICHOARTUS CORBULA | PHORMOSTICHOARTUS FISTULA | PHORMOSTICHOARTUS SP. | PHORTICIUM POLYCLADUM | SIPHOCAMPE ARACHNEA | SIPHOCAMPE NODOSARIA | SPIROCYRTIS(?) SUBSCALARIS | SPONGOCORE PUER | SPONGOPYLE OSCULOSA | SPONGOTROCHUS (?)VENUSTUM | SPONGOTROCHUS GLACIALIS | SPONGURUS(?) SP. | STICHOCORYS PEREGRINA | STICHOPERA PECTINATA | STYLODICTYA VALIDISPINA | THEOCALYPTRA BICORNIS | THEOCORYS REDONDOENSIS | THEOCORYS SP. | XIPHOSPIRA SP. CF. X. CIRCULARIS | TOTAL SPECIES PRESENT |
|---|---|---

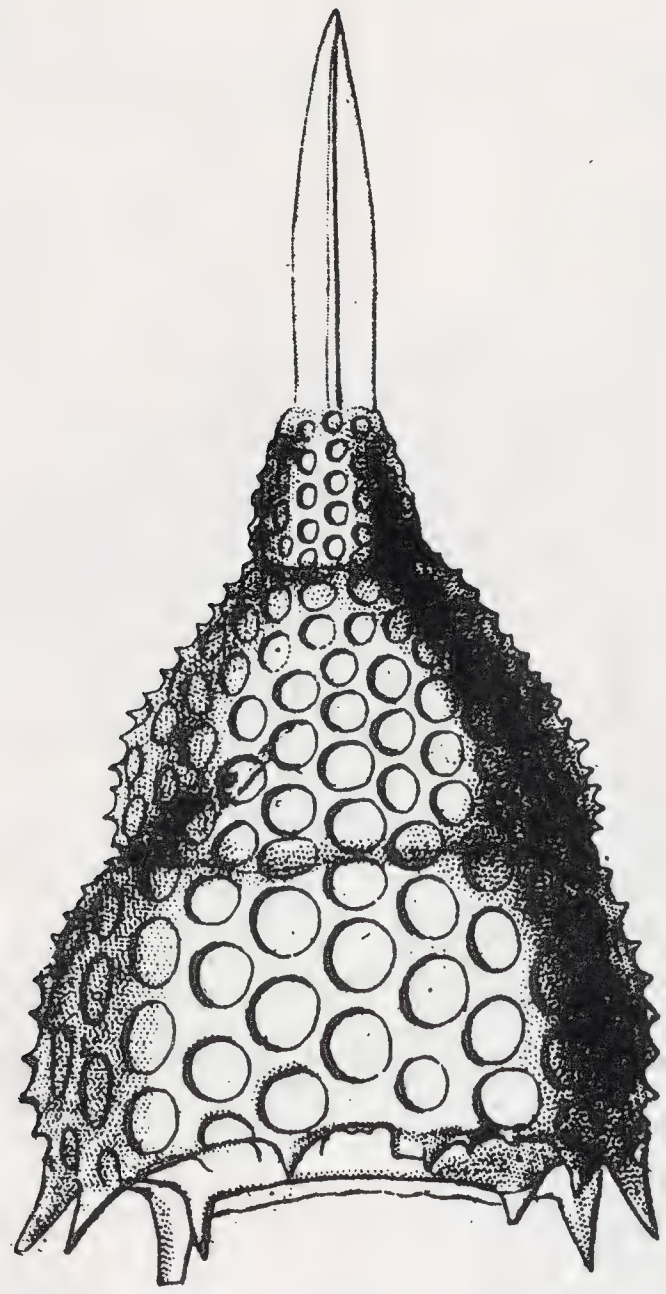
Check Chart II
Sweeny Road Radiolarians
Last Appearance Datum

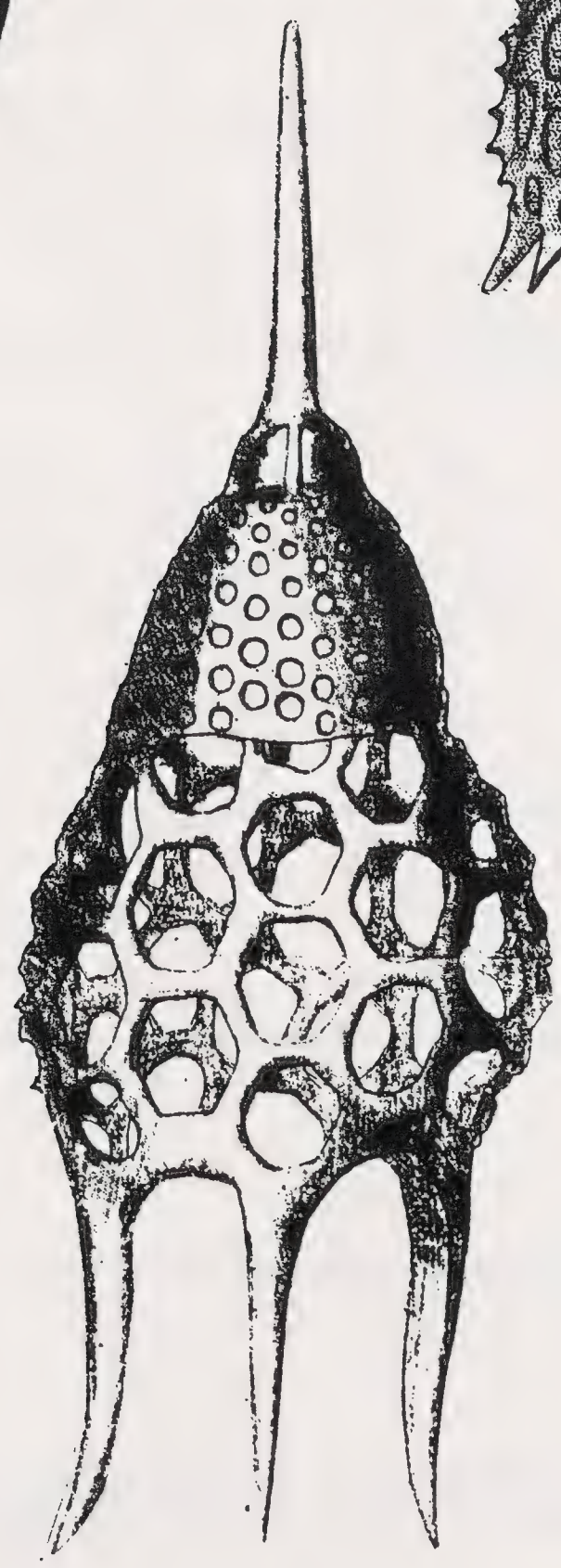
| Sample Number \ Taxa | HYMENIASTRUM SPP. | LAMPROCYRTIS HETEROPOROS | LITHATRACTUS TIMMSI | LITHELIUS NAUTILOIDES | PHORMOSTICHOARTUS FISTULA | SPONGOTROCHUS (?)VENUSTUM | SPONGOTROCHUS GLACIALIS | STYLODICTYA VALIDISPINA | THEOCALYPTRA BICORNIS | XIPHOSPIRA SP. CF. X. CIRCULARIS | ACANTHODESMID SPP. | ANTARCTISSA DENTICULATA | ANTARCTISSA SP. GP. 3 | BOTRYOSTROBUS BRAMLETTEI | CLATHROCYCLAS CABRILLOENSIS | CORNUTELLA PROFUNDA | CYRTOCAPSELLA CORNUTA | DICTYOPHIMUS(?) SP. | LYCHNOCANOMA GRANDE | PHORMOSTICHOARTUS SP. | PHORTICIUM POLYCLADUM | STICHOCORYS PEREGRINA | BOTRYOSTROBUS AURITUS/AUSTRALIS GROUP | SPONGURUS(?) SP. | ACTINOMMA SPP. | EUCYRTIDIUM SP. CF. E. CALVERTENSE | LITHOCARPIUM POLYACANTHA | ANTARCTISSA SP. GP. 2 | LARCOSPIRA QUADRANGULA | THEOCORYS SP. | ANTARCTISSA SP. GP. 1 | LAMPROCYRTIS(?) HANNAI | CARPOCANIIDAE, GEN. ET SP. INDET. | SPONGOPYLE OSCULOSA | CHALLENGERON DIODON | THEOCORYS REDONDOENSIS | HEXACONTIUM SPP. | LITHELIUS MINOR | CIRCODISCUS MICROPORUS | AXOPRUNUM ANGELINUM | BATHROPYRAMIS WOODRINGI | PHORMOSTICHOARTUS CORBULA | ANTHOCYRTIDIUM OPHIRENSE | SPONGOCORE PUER | SIPHOCAMPE ARACHNEA | BOTRYOSTROBUS SP. CF. B. MIRALESTENSIS | CROMYDRUPPOCARPUS ESTERAE | DICTYOPHIMUS CRISIAE | LYCHNOCANOMA SP. | SIPHOCAMPE NODOSARIA | SPIROCYRTIS(?) SUBSCALARIS | STICHOPERA PECTINATA | CYRTOCAPSELLA TETRAPERA | TOTAL SPECIES PRESENT |
|---|---|---

Check Chart III
Sweeny Road Radiolarians
First Appearance Datum

| Sample Number \ Taxa | LITHELIUS NAUTILOIDES | SPONGOTROCHUS GLACIALIS | STICHOCORYS PEREGRINA | XIPHOSPIRA SP. CF. X. CIRCULARIS | CIRCODISCUS MICROPORUS | LITHATRACTUS TIMMSI | LITHOCARPIUM POLYACANTHA | PHORTICIUM POLYCLADUM | LYCHNOCANOMA GRANDE | CYRTOCAPSELLA TETRAPERA | BOTRYOSTROBUS BRAMLETTEI | LITHELIUS MINOR | CARPOCANIIDAE, GEN. ET SP. INDET. | ACTINOMMA SPP. | DICTYOPHIMUS(?) SP. | ACANTHODESMID SPP. | SPONGOTROCHUS (?)VENUSTUM | ANTARCTISSA SP. GP. 1 | AXOPRUNUM ANGELINUM | BOTRYOSTROBUS AURITUS/AUSTRALIS GROUP | BOTRYOSTROBUS SP. CF. B. MIRALESTENSIS | CORNUTELLA PROFUNDA | CROMYDRUPPOCARPUS ESTERAE | DICTYOPHIMUS CRISIAE | HEXACONTIUM SPP. | LARCOSPIRA QUADRANGULA | LYCHNOCANOMA SP. | PHORMOSTICHOARTUS SP. | SIPHOCAMPE NODOSARIA | SPIROCYRTIS(?) SUBSCALARIS | STICHOPERA PECTINATA | BATHROPYRAMIS WOODRINGI | HYMENIASTRUM SPP. | LAMPROCYRTIS(?) HANNAI | PHORMOSTICHOARTUS CORBULA | SIPHOCAMPE ARACHNEA | SPONGOCORE PUER | SPONGOPYLE OSCULOSA | STYLODICTYA VALIDISPINA | THEOCALYPTRA BICORNIS | ANTHOCYRTIDIUM OPHIRENSE | ANTARCTISSA DENTICULATA | LAMPROCYRTIS HETEROPOROS | EUCYRTIDIUM SP. CF. E. CALVERTENSE | THEOCORYS SP. | CHALLENGERON DIODON | THEOCORYS REDONDOENSIS | CLATHROCYCLAS CABRILLOENSIS | ANTARCTISSA SP. GP. 3 | ANTARCTISSA SP. GP. 2 | PHORMOSTICHOARTUS FISTULA | SPONGURUS(?) SP. | CYRTOCAPSELLA CORNUTA | TOTAL SPECIES PRESENT |
|---|---|---







PART III
DIATOMS

R. J. NAVARRETTE

CONTENTS

Page
I. INTRODUCTION 39
II. SYSTEMATIC PALEONTOLOGY 40

ILLUSTRATIONS

PLATES 1-11 . . . . . beginning on page 44
CHECK CHART I, Diatoms (alphabetized) 67
CHECK CHART II, Diatoms (last appearance datum) 73
CHECK CHART III, Diatoms (first appearance datum) 79

I. INTRODUCTION

An illustrated inventory of the diatoms that occur in the Neogene rocks of the Sweeny Road section was the primary objective of this study. Our check charts provide the relative frequencies in which the various taxa were observed throughout the section. Critical taxonomy of diatoms is hampered by the unavailability of some of the early literature. This situation has often required the adoption of the interpretations of modern authors as to the intentions of earlier systematists, whose data may often have been tempered with artistic license. To this small but select body of contemporary diatomists, whose references are copiously cited herein, we extend our gratitude for their pioneer efforts, as well as our sympathy for their problems with a time-ravaged and increasingly multilingual bibliography.

Diatoms are proving to be the most useful group of organisms for chronostratigraphy in widespread regions of Neogene rocks in both onshore and offshore California. Planktonic forminifera and calcareous nannofossils, so useful in low latitudes, did not have the diversity of species and genera in the colder Miocene to Holocene seas of the North Pacific that they enjoyed in tropical and subtropical waters. Radiolarians and silicoflagellates are useful chronostratigraphic markers in Miocene to Holocene regions of the North Pacific, but assemblages of these organisms have a much lower species diversity than do the diatom floras, especially in land-based sections.

The development of siliceous chronostratigraphic models for middle to high latitudes has been a major break-through in global biostratigraphy. Among the contributors of significant data on diatoms should be mentioned Burckle (1972) for a low latitude zonation, Koizumi (1975) for a high latitude zonation, and Schrader (1973a) and Barron (1976) for the nearshore transitional zonation used in California. Subsequent data, such as provided by Barron and Von Huene (1978) and DSDP Hole 438A, have related paleogeographic zones and correlated diatom events with paleomagnetic stratigraphy. The correlation of diatom events (earliest occurrence and last occurrence of key forms) with the magnetic time scale provides absolute ages by which sediment accumulation rates may be derived. Figure 1 lists forms, identified in the section at Sweeny Road, that have been used by biostratigraphers to zone and date Neogene formations in the North Pacific region (Barron, 1975, 1976; Schrader, 1973a; Dumont, 1984).

Estimated dates (m.y.) are noted for the first appearance (FAD) and last appearance (LAD) of these diatoms. In several cases only a geological age is given for the range.

Diatoms are commonly reworked, and great care must be taken in interpreting the age of beds in which they occur. The occurrence of *Denticulopsis dimorpha* in sample 43, for example, is considered to be anomalous, because the last occurrence of this species is well established at 9.9 m.y., and ample other diatom events indicate that the oldest diatom yielding interval, sample 39, was deposited after that date in the succession at Sweeny Road.

All illustrations are Polaroid prints from type 667 film, except as otherwise noted, when 35 mm film was used. The taxonomic designation for each figure is followed in order by the horizon (sample) number, the sieve fraction, and the magnification. The prefix, CRC 40396, was assigned to all sam-

ples collected from the Sweeny Road section, but most references to horizons and samples in this report are cited without the prefix. The diatoms are illustrated in approximately alphabetical order by genus and species, as listed in the catalog of species.

II. SYSTEMATIC PALEONTOLOGY

The following catalog of diatoms from the Sweeny Road section is arranged in alphabetical order by genus and by species within each genus. This procedure adopts the format of contemporary authors to facilitate use of this report as a reference for Neogene species.

Diatom nomenclature is generally hampered by the unavailability of some of the early literature, and confusion has arisen by the use of inadequate optical equipment and slide mounting media. We are grateful to H. J. Schrader (personal communication) for his emphasis on the minimum magnification and resolution necessary for light microscopy and photography of the smaller diatoms, such as *Denticulopsis* spp., among which there are so many key markers.

Genus ACTINOCYCLUS Ehrenberg, 1838

ACTINOCYCLUS CHOLNOKYI
Van Landingham
Pl. 1, fig. 1

Actinocyclus cholnokyi VAN LANDINGHAM, 1967, I, p. 83; BARRON, 1975, pl. 1, fig. 2, 3 (with synonymy and distribution)
Actinocyclus divisus (Grunow) KOIZUMI, 1968, p. 207, pl. 32, fig. 3 (with description)

ACTINOCYCLUS CUBITUS Hanna and Grant
Pl. 1, fig. 2

Actinocyclus cubitus HANNA and GRANT, 1926, p. 118, pl. 11, fig. 3; BARRON, 1975, p. 117, pl. 1, fig. 4

ACTINOCYCLUS CURVATULUS Janisch
Pl. 1, fig. 3

Actinocyclus curvatulus Janisch *in* Schmidt, 1878; KOIZUMI, 1973a, p. 831, fig. 1-6 (with description)

ACTINOCYCLUS EHRENBERGII Ralfs
Pl. 1, fig. 5

Actinocyclus ehrenbergii Ralfs *in* Pritchard, 1861; SCHRADER, 1973, p. 701, pl. 19, fig. 1

	FAD	LAD m.y.
Actinocyclus ingens	17.8	4.5
Denticulopsis hustedtii	14.0	11-3 (common)
D. hyalina	15.0	7.0
D. kamtschatica	6.7	2.4
D. seminae var. *fossilis*	4.3	
Lithodesmium asketogonium	*Upper Miocene*	
L. cornigerum	*Lower Pliocene*	
Nitzschia jouseae	4.5	2.6
N. miocenica	6.8	5.5
N. reinholdii	6.8	0.65
Pseudoeunotia doliolus	1.8	0
Rhizosolenia barboi	11.2	0.4
Rouxia californica	15.0	6.2 (common)
Thalassiosira antiqua	7.6	1.7
T. convexa var. *aspinosa*	6.0	2.2
T. miocenica	6.15	5.05
T. nativa	11.0	3.2
T. oestrupii	5.0	0
T. praeconvexa	6.2	5.5

Figure 1. Diatom taxa from the Sweeny Road outcrop that have been used for dating Neogene sections in the North Pacific region (Barron, 1975, 1976; Barron, in press; Schrader, 1973).

ACTINOCYCLUS EHRENBERII Ralfs
var. ASTERISCUS Barron
Pl. 1, fig. 4

Actinocyclus ehrenbergii var. *asteriscus* BARRON, 1975, p. 117-118, pl. 1, fig. 9

ACTINOCYCLUS EHRENBERGII Ralfs
var. TENELLA Brébisson
Pl. 1, fig. 6

Eupodiscus tenellus BRÉBISSON, 1854, pl. 1, fig. 9 (inaccessible)
Actinocyclus ehrenbergii var. *tenella* (Brébisson) HUSTEDT, 1929, p. 530, fig. 302; BARRON, 1975, p. 118, pl. 1, fig. 6

ACTINOCYCLUS ELLIPTICUS Grunow
Pl. 1, fig. 7

Actinocyclus ellipticus Grunow *in* Van Heurck, 1881, *fide* SCHRADER, 1973, p. 701, pl. 8, fig. 7-9, 11-14, 16, 17

ACTINOCYCLUS ELLIPTICUS Grunow
var. MORONENSIS (Deby)
Pl. 1, fig. 8

Actinocyclus ellipticus Grunow var. *moronensis* (Deby) *fide* KOLBE, 1954, p. 21, pl. 3, fig. 29, 30; BARRON, 1975, p. 118, pl. 1, fig. 8

ACTINOCYCLUS INGENS Rattray
Pl. 1, fig. 9-10

Actinocyclus ingens RATTRAY, 1890, p. 149, pl. 11, fig. 7, *fide* KANAYA, 1959, p. 97, pl. 7, fig. 6-9; pl. 8, fig. 1-4; BARRON, p. 118, pl. 1, fig. 10, 12, 13, 16

ACTINOCYCLUS OCHOTENSIS Jousé
Pl. 1, fig. 11

Actioncyclus ochotensis JOUSÉ, 1968, fig. 2, no. 2, 5, *fide* KOIZUMI, 1968, p. 208, pl. 32, fig. 7-10; SCHRADER, 1973, pl. 18, fig. 8, 15, 17; p. 19, fig. 6 (with description)

Modern distribution: planktonic, northboreal (Barron, 1975, p. 118)

ACTINOCYCLUS OCULATUS Jousé
Pl. 1, fig. 12

Actinocyclus oculatus Jousé, 1961, *fide* KOIZUMI, 1968, p. 208, pl. 32, fig. 11-14 (with description)

ACTINOCYCLUS TSUGARUENSIS Kanaya
Pl. 1, fig. 13

Actinocyclus tsugaruenis KANAYA, 1959, p. 99, pl. 8, fig. 5-8 (with description); BARRON, 1975, p. 119, pl. 1, fig. 15

Genus ACTINOPTYCHUS Ehrenberg, 1839

ACTINOPTYCHUS BISMARCKII Schmidt
Pl. 2, fig. 1

Actinoptychus bismarckii SCHMIDT, 1886, pl. 91, fig. 4; WORNARDT, 1967, pl. 42, fig. 65 (with description)

ACTINOPTYCHUS CLEVEI Schmidt
Pl. 2, fig. 2

Actinoptychus clevei SCHMIDT, 1886, pl. 91, fig. 1; BARRON, 1975, p. 119, pl. 2, fig 6

ACTINOPTYCHUS SPLENDENS Shadbolt
var. HALIONYX Grunow
Pl. 2, fig. 3

Actinoptychus splendens Shadbolt var. *halionyx* Grunow *in* Van Heurck, 1883, *fide* BARRON, 1974, p. 120, pl. 2, fig. 4

ACTINOPTYCHUS SPLENDENS Shadbolt
var. INCISA Grunow
Pl. 2, fig. 4

Actinoptychus splendens Shadbolt var. *incisa* Grunow *in* SCHMIDT, 1890, pl. 154, fig. 2, 3; WORNARDT, 1967, p. 48, fig. 68-71, 73

ACTINOPTYCHUS STELLA Schmidt
var. CLEVEI Schmidt, Wornardt
Pl. 2, fig. 5

Actinoptychus clevei SCHMIDT, 1886, pl. 91, fig. 1
Actinoptychus stella var. *clevei* Schmidt, WORNARDT, 1967, p. 48, fig. 78

Remarks: "The little difference between the typical species of *Actinoptychus stella* and *Actinoptychus clevei* Schmidt is not of the specific magnitude, and so I have placed it as a variety of the species *Actinoptychus stella*" (Wornardt, 1967, p. 48).

ACTINOPTYCHUS UNDULATUS (Bailey) Ralfs
Pl. 2, fig. 6

Actinoptychus undulatus (Bailey) Ralfs *in* Pritchard, 1861, *fide* SCHRADER, 1973, p. 702, pl. 22, fig. 4, 12, 15, 17 (?)

ACTINOPTYCHUS VULGARIS Schumann
var. MONICAE Grunow
Pl. 2, fig. 7

Actinoptychus vulgaris Schumann var. *monicae* Grunow *in* VAN HUERCK, 1883, pl. 121, fig. 9; WORNARDT, 1967, pl. 51, pl. 47, fig. 79-81 (with description)

Genus ARACHNOIDISCUS Deane *ex* Pritchard, 1852

ARACHNOIDISCUS DECORUS Brown
Pl. 2, fig. 8

Arachnoidiscus decorus BROWN, 1933, p. 71, pl. 6, fig. 3; WORNARDT, 1967, p. 40, p. 41, fig. 53

ARACHNOIDISCUS EHRENBERGII Bailey *ex* Ehrenberg
Pl. 2, fig. 9

Arachnoidiscus ehrenbergii Bailey *ex* EHRENBERG, 1849, p. 64; BARRON, 1975, p. 121, p. 2, fig. 15

Modern distribution: "littoral, favors tropical and subtropical waters . . . probably spends part of its time as a bottom form, epiphytic" (Hendey, 1937, p. 267).

ARACHNOIDISCUS ORNATUS Ehrenberg var. MONTEREYANUS Schmidt
Pl. 2, fig. 10

Arachnoidiscus ornatus Ehrenberg var. *montereyanus* SCHMIDT, 1882, pl. 73, fig. 8, 9; BARRON, 1975, p. 122, pl. 3, fig. 1

Genus ASTEROMPHALUS Ehrenberg, 1844

ASTEROMPHALUS DARWINII Ehrenberg
Pl. 2, fig. 11

Asteromphalus darwinii EHRENBERG, 1844, p. 200, pl. (June), fig. 1; BARRON, 1975, p. 122, pl. 3, fig. 4

Genus AULACODISCUS Ehrenberg, 1844

AULACODISCUS CONCENTRICUS (Mann) Boyer
Pl. 2, fig. 12

Tripodiscus concentricus MANN, 1907, p. 278, pl. 54, fig. 1, 2

Aulacodiscus concentricus (Mann) BOYER, 1926, p. 76; BARRON, 1975, p. 123, pl. 3, fig. 10

AULACODISCUS KITTONII Arnott
Pl. 3, fig. 1

Aulacodiscus kittonii Arnott *in* PRITCHARD, 1861, p. 844, pl. 8, fig. 24; BARRON, 1975, p. 123, pl. 3, fig. 11

AULACODISCUS MARGARITACEUS Ralfs
Pl. 3, fig. 2

Aulacodiscus margaritaceus Ralfs *in* PRITCHARD, 1861, p. 844; BARRON, 1975, p. 123, pl. 3, fig. 8

AULACODISCUS SIMPLEX Rattray
Pl. 3, fig. 3

Aulacodiscus simplex RATTRAY, 1888, p. 340; BARRON, 1975, p. 123, pl. 3, fig. 9

Genus AULISCUS Brun *in* Schmidt, 1882

AULISCUS CAELATUS Bailey
Pl. 3, fig. 4

Auliscus caelatus BAILEY, 1853, p. 6, pl. 1, fig. 3, 4; BARRON, 1975, p. 124, pl. 4, fig. 1

AULISCUS CAELATUS Bailey var. CONSTRICTA Rattray
Pl. 3, fig. 5

Auliscus caelatus var. *constricta* RATTRAY, 1888, p. 887, pl. 15, fig. 8; WORNARDT, 1967, p. 53, fig. 88-91, 95

AULISCUS PUNCTATUS Bailey
Pl. 3, fig. 6

Auliscus punctatus BAILEY, 1853, p. 5, pl. 1, fig. 9; BARRON, 1975, p. 125, pl. 4, fig. 6

Genus BACTERIASTRUM Shadbolt, 1853

BACTERIASTRUM sp.
Pl. 3, fig. 7

Modern distribution: Oceanic; commonly found in tropical waters (Hendey, 1937, p. 308).

Genus BIDDULPHIA Gray, 1821

BIDDULPHIA AURITA (Lyngbye) Brébisson and Godey
Pl. 3, fig. 8

Diatoma auritum LYNGBYE, 1819, pl. 182, pl. 652, fig. D

Biddulphia aurita (Lygbye) BRÉBISSON and GODEY, 1838, p. 12; WORNARDT, 1967, p. 60, p. 63, fig. 113

BIDDULPHIA AURITA (Lyngbye) Brébisson and Godey var. OBTUSA (Kützing) Hustedt
Pl. 3, fig. 9

Odontella obtusa KÜTZING 1844, p. 137, pl. 18, fig. 8, 1-3, 6-8
Biddulphia aurita (Lyngbye) Brébisson and Godey var. *obtusa* (Kützing) HUSTEDT, 1930, p. 848-849, fig. 502; WORNARDT, 1967, p. 60, pl. 63, fig. 116

BIDDULPHIA RHOMBUS (Ehrenberg) Wm. Smith
Pl. 3, fig. 10

Zygoceros rhombus EHRENBERG, 1839, p. 80, pl. 4, fig. 11
Biddulphia rhombus (Ehrenberg) WM. SMITH, 1856, p. 49, pl. 45, fig. 320; pl. 61, fig. 320; WORNARDT, 1967, p. 62, p. 63, fig. 118

Modern distribution: Widespread, neritic (Hendey, 1854, p. 103.

BIDDULPHIA SUBORBICULARIS Grunow
Pl. 3, fig.11

Biddulphia suborbicularis Grunow *in* VAN HEURCK, 1882, p. 100, fig. 15, 16; BARRON, 1975, p. 126, pl. 4, fig. 17

BIDDULPHIA TRIDENS (Ehrenberg) Ehrenberg
Pl. 3, fig. 12, 13

Denticella tridens EHRENBERG, 1838, p. 129
Biddulphia tridens (Ehrenberg) EHRENBERG, 1840, p. 205 (according to Boyer, 1926, p. 121); BARRON, 1975, p. 126, pl. 4, fig. 12, 13

Genus CESTODISCUS Greville, 1865

CESTODISCUS PULCHELLUS Greville var. MACULATUS Kolbe
Pl. 3, fig. 14

Cestodiscus pulchellus Greville var. *maculatus* KOLBE, 1954, p. 25, pl. 1, fig. 8

Genus CHAETOCEROS Ehrenberg, 1844

CHAETOCEROS CINCTUS Gran (resting spore)
Pl. 3, fig. 15

Chaetoceros cinctus GRAN, 1897, p. 24, pl. 2, fig. 23-27; BARRON, 1975, p. 127, pl. 5, fig. 4

CHAETOCEROS DIADEMA (Ehrenberg) Gran (resting spore)
Pl. 3, fig. 16

Syndendrium diadema EHRENBERG, 1854, pl. 35a, fig. 18
Chaetoceros diadema (Ehrenberg) GRAN, 1897, p. 20, p. 2, fig. 16-18; BARRON, 1975, p. 128, pl. 5, fig. 5

CHAETOCEROS DICLADIA Castracane (resting spore)
Pl. 3, fig. 17

Chaetoceros dicladia CASTRACANE, 1886, p. 82, pl. 8, fig. 1, pl. 19, fig. 7, 8; BARRON, 1975, p. 128, pl. 5, fig. 6, 7

CHAETOCEROS sp. (spore) Schrader
Pl. 4, fig. 1

Chaetoceros sp. (spore) SCHRADER, 1973, p. 702, pl. 17, fig. 5, 6, 7

Genus CLADOGRAMMA Ehrenberg, 1844

CLADOGRAMMA CALIFORNICUM Ehrenberg
Pl. 4, fig. 2

Cladogramma californicum EHRENBERG, 1854, pl. 33, fig. 13; BARRON, 1975, p. 128, pl. 5, fig. 9

CLADOGRAMMA DUBIUM Lohman
Pl. 4, fig. 3

Cladogramma dubium LOHMAN, 1948, p. 168, pl. 9, fig. 5; BARRON, 1975, p. 128, pl. 5, fig. 10

Genus COCCONEIS Ehrenberg, 1838

COCCONEIS COSTATA Gregory
Pl. 4, fig. 4

Cocconeis costata GREGORY, 1855, p. 39, pl. 4, fig. 10; BARRON, 1975, p. 129, pl. 5, fig. 12

COCCONEIS DECIPIENS Cleve
Pl. 4, fig. 5

Cocconeis decipiens CLEVE, 1873, p. 14, fig. 1, pl. 6; BARRON, 1975, p. 129, pl. 5, fig. 13

COCCONEIS DIRUPTA Gregory var. TRIUMPHIS (Hanna and Grant) Fenguelli
Pl. 4, fig. 6

Cocconeis triumphis HANNA and GRANT, 1926, p. 135, pl. 14, fig. 11-13
Cocconeis dirupta Gregory var. *triumphis* (Hanna and Grant) FRENGUELLI, 1949, p. 111, pl. 6, fig. 9; BARRON, 1975, p. 129, pl. 5, fig. 15

Genus COSCINODISCUS Ehrenberg, 1838

COSCINODISCUS ANTIQUUS (Grunow) Rattray
Pl. 4, fig. 7

Coscinodiscus (excentricus var.?) *antiquus* GRUNOW, 1884, p. 84, pl. 4, fig. 24

Coscinodiscus antiquus (Grunow) RATTRAY, 1890, p. 461, fig. 13; WORNARDT, 1967, p. 20, p. 29, fig. 23

COSCINODISCUS ASTEROMPHALUS Ehrenberg

Pl. 4, fig. 8

Coscinodiscus asteromphalus EHRENBERG, 1844, p. 77; WORNARDT, 1967, p. 20, fig. 14-18

COSCINODISCUS BIRADIATUS Greville

Pl. 4, fig. 9

Coscinodiscus biradiatus GREVILLE, 1861, p. 42, pl. 4, fig. 7; BARRON, 1975, p. 132, pl. 6, fig. 4

COSCINODISCUS EXCENTRICUS Ehrenberg var. LEASAREOLATUS Kanaya

Pl. 4, fig. 10

Coscinodiscus excentricus Ehrenberg var. *leasareolatus* Kanaya, 1966, *fide* KOIZUMI, 1973, p. 832, pl. 3, fig. 7-10

COSCINODISCUS HIROSAKIENSIS Kanaya

Pl. 4, fig. 11

Coscinodiscus hirosakiensis KANAYA, 1959, p. 78, pl. 4, fig. 1, 2 (with description); BARRON, 1975, pl. 4, fig. 13

COSCINODISCUS KURZII Grunow

Pl. 4, fig. 12

Coscinodiscus kurzii Grunow *in* SCHMIDT, 1888, pl. 113, fig. 17; BARRON, 1975, p. 133, pl. 6, fig. 19

COSCINODISCUS MARGINATUS Ehrenberg

Pl. 5, fig. 1

Coscinodiscus marginatus EHRENBERG, 1841, p. 142; EHRENBERG 1854, pl. 18, fig. 44, pl. 33, fig. 12; BARRON, 1975, pl. 134, pl. 7, fig. 1

Modern distribution: "An oceanic species frequent in North Atlantic water, North Sea" (Hendey, 1964, p. 78). North boreal (Jousé *et al.*, 1969).

COSCINODISCUS MONICAE (Grunow) Rattray

Pl. 5, fig. 3

Coscinodiscus janischii var. *monicae* GRUNOW, 1884, p. 76

Coscinodiscus monicae Grunow RATTRAY, 1890, p. 563, pl. 115; BARRON, 1975, p. 134, pl. 7, fig. 2

COSCINODISCUS NITIDUS Gregory

Pl. 5, fig. 2

Coscinodiscus nitidus GREGORY, 1857, pl. 27, pl. 2, fig. 45; BARRON, 1975, p. 134, pl. 7, fig. 3

Modern distribution: "Neritic, in coastal regions of all seas" (Cupp, 1943, p. 55).

COSCINODISCUS NODULIFER Schmidt

Pl. 5, fig. 4

Coscinodiscus nodulifer Schmidt *in* Schmidt, 1878, *fide* KOLBE, 1954, p. 33, pl. 3, fig. 35, 36 (with description); BARRON, 1975, p. 135, pl. 7, fig. 4

Modern distribution: Tropical, planktonic (Jousé *et al.*, 1969).

COSCINODISCUS OBSCURUS Schmidt

Pl. 5, fig. 6

Coscinodiscus obscurus Schmidt *in* SCHMIDT, 1878, pl. 61, fig. 16; BARRON, 1975, p. 135, pl. 7, fig. 4

PLATE 1

1. *Actioncyclus cholnokyi* Van Landingham. 73, -28 microns, x1000.
2. *Actinocyclus cubitus* Hanna and Grant. 43, +28 microns, x780.
3. *Actinocyclus curvatulus* Janisch. 69, +28 microns, x540, 35 mm.
4. *Actinocyclus ehrenbergii* Ralfs var. *asteriscus* Barron. 51, +28 microns, x540.
5. *Actinocyclus ehrenbergii* Ralfs. 57, +28 microns, x960.
6. *Actinocyclus ehrenbergii* Ralfs var. *tenella* Brébisson. 73, -28 microns, x1000.
7. *Actinocyclus ellipticus* Grunow. 43, +28 microns, x940.
8. *Actinocyclus ellipticus* Grunow var. *moronesis* (Deby). 43, +28 microns, x 960.

9-10. *Actinocyclus ingens* Rattray. Fig. 9, 58, +28 microns, x640. Fig. 10, 54, +28 microns, x640.

11. *Actinocyclus ochotensis* Jousé. 60, -28 microns, x1300.
12. *Actinocyclus oculatus* Jousé. 60, -28 microns, x 1300.
13. *Actinocyclus tsugaruensis* Kanaya. 54, +28 microns, x740, 35 mm.

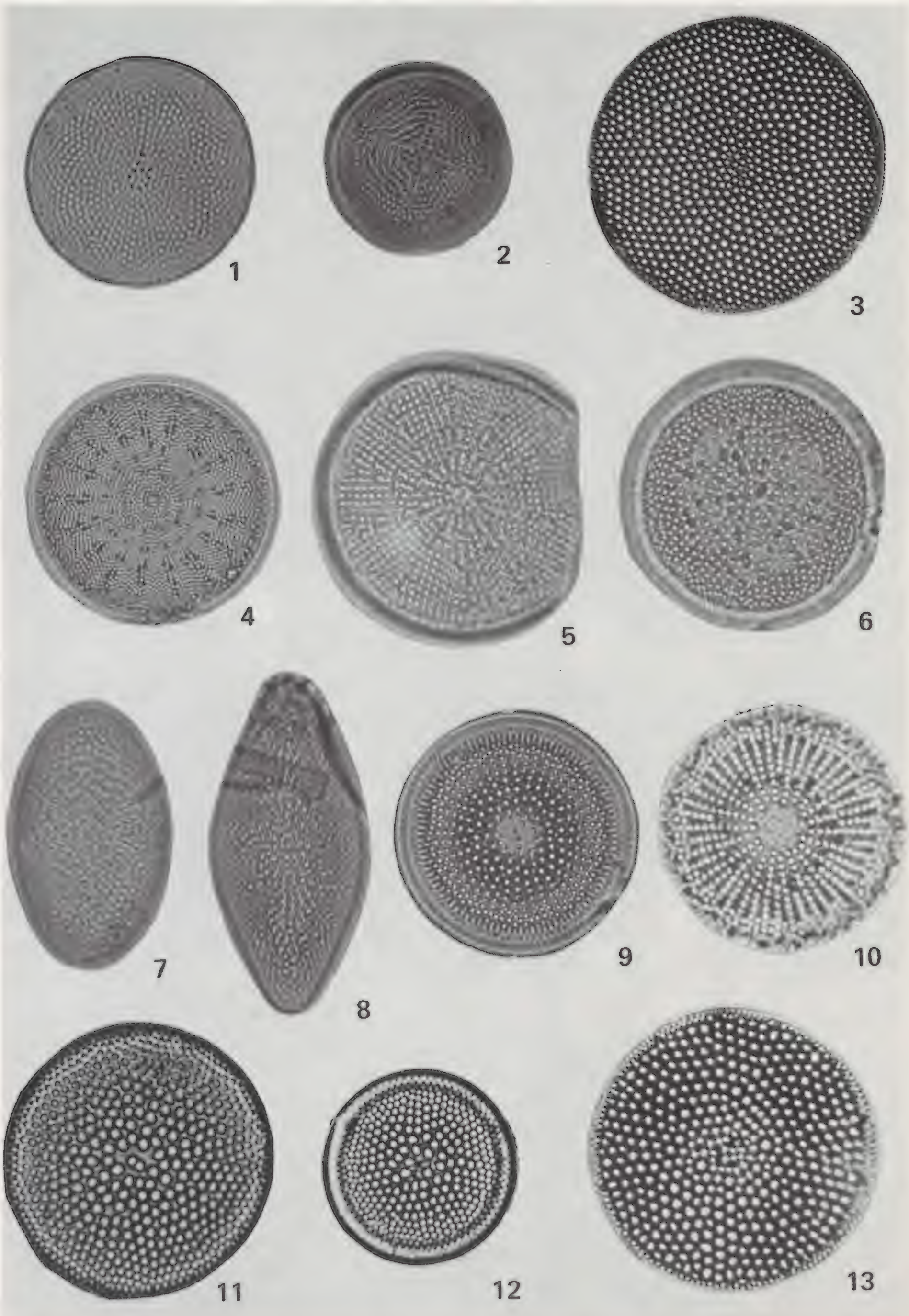


PLATE 1

COSCINODISCUS OCULUSIRIDIS Ehrenberg var. BOREALIS (Bailey) Cleve
Pl. 5, fig. 7

Coscinodiscus borealis BAILEY, 1856, p. 3
Coscinodiscus oculusiridis Ehrenberg var. *borealis* (Bailey) CLEVE, 1883, p. 488; BARRON, 1975, p. 135, pl. 7, fig. 6

COSCINODISCUS OCULUSIRIDIS (OCULUS-IRIDIS) Ehrenberg var. OCULUSIRIDIS Barron
Pl. 5, fig. 8

Coscinodiscus oculusiridis (oculus-iridis) EHRENBERG, 1839, p. 147
Coscinodiscus oculusiridis Ehrenberg var. *oculusiridis* BARRON, 1975, p. 135, pl. 7, fig. 9

COSCINODISCUS PILOSUS Schmidt
Pl. 5, fig. 5

Coscinodiscus pilosus SCHMIDT, 1890, p. 148, fig. 8; BARRON, 1975, p. 135, pl. 7, fig. 8

COSCINODISCUS PLICATUS Grunow
Pl. 5, fig. 9

Coscinodiscus plicatus Grunow *in* SCHMIDT, 1878, p. 59, fig. 1; BARRON, 1975, p. 136, pl. 7, fig. 10

COSCINODISCUS RADIATUS Ehrenberg
Pl. 6, fig. 2

Coscinodiscus radiatus EHRENBERG, 1839, p. 148, pl. 3, fig. 1a-c; BARRON, 1975, p. 136, pl. 7, fig. 12, 16

COSCINODISCUS ROBUSTUS Greville var. INCRETUS Schmidt, Wornardt
Pl. 6, fig. 3

Coscinodiscus robustus Greville, SCHMIDT, 1886, pl. 62, fig. 16, 17
Coscinodiscus incretus SCHMIDT, 1888, pl. 139, fig. 1, 1a
Coscinodiscus robustus Greville var. *incretus* Schmidt, WORNARDT, 1967, p. 32, fig. 43

COSCINODISCUS STELLARIS Roper var. SYMBOLOPHORA (Grunow) Jørgensen
Pl. 6, fig. 4

Coscinodiscus stellaris Roper var. *symbolophora* (Grunow) JØRGENSEN, 1905, p. 196; KOIZUMI, 1973, p. 832, pl. 4, fig. 5

COSCINODISCUS SUBTILIS Ehrenberg
Pl. 6, fig. 5

Coscinodiscus subtilis EHRENBERG, 1841, p. 412, pl. 1, fig. 3; BARRON, 1975, p. 136, pl. 7, fig. 17, 18

COSCINODISCUS TABULARIS Grunow var. EGREGIUS (Rattray) Hustedt
Pl. 6, fig. 6

Coscinodiscus tabularis Grunow var. *egregius* (Rattray) Hustedt, 1928, p. 428, fig. 230b, *fide* SCHRADER, 1973, p. 704, pl. 20, fig. 3, 4

COSCINODISCUS VETUSTISSIMUS Pantocsek
Pl. 6, fig. 7

Coscinodiscus vetustissimus Pantocsek, 1886, p. 71, pl. 20, fig. 186, *fide* BARRON, 1975, p. 137, pl. 7, fig. 15

Genus DENTICULOPSIS Simonsen, 1979

DENTICULOPSIS DIMORPHA (Schrader) Simonsen
Pl. 6, fig. 8

Denticula lauta BAILEY, SIMONSEN and KANAYA, 1961, pl. 1, fig. 9-10 (with synonymy)

PLATE 2

1. *Actinoptychus bismarckii* Schmidt. 73, -28 microns, x1000.
2. *Actinoptychus clevei* Schmidt. 52, -29 microns, x1000, 35 mm.
3. *Actinoptychus splendens* Shadbolt var. *halionyx* Grunow. 73, +28 microns, x700.
4. *Actinoptychus splendens* Shadbolt var. *incisa* Grunow. 65, +28 microns, x287.5.
5. *Actinoptychus stella* Schmidt var. *clevei* Schmidt, Wornardt. 73, +28 microns, x700, 35 mm.
6. *Actinoptychus undulatus* (Bailey) Ralfs. 58, +28 microns, x50.
7. *Actinoptychus vulgaris* Schumann var. *monicae* Grunow. 65, +28 microns, x337.5.
8. *Arachnoidiscus decorus* Brown. 39, +28 microns, x275.
9. *Arachnoidiscus ehrenbergii* Bailey *ex* Ehrenberg. 56, +28 microns, x300.
10. *Arachnoidiscus ornatus* Ehrenberg var. *montereyanus* Schmidt. 42, +28 microns, x250.
11. *Asteromphalus darwinii* Ehrenberg. 56, +28 microns, x520.
12. *Aulacodiscus concentricus* (Mann) Boyer. 52, +28 microns, x400.

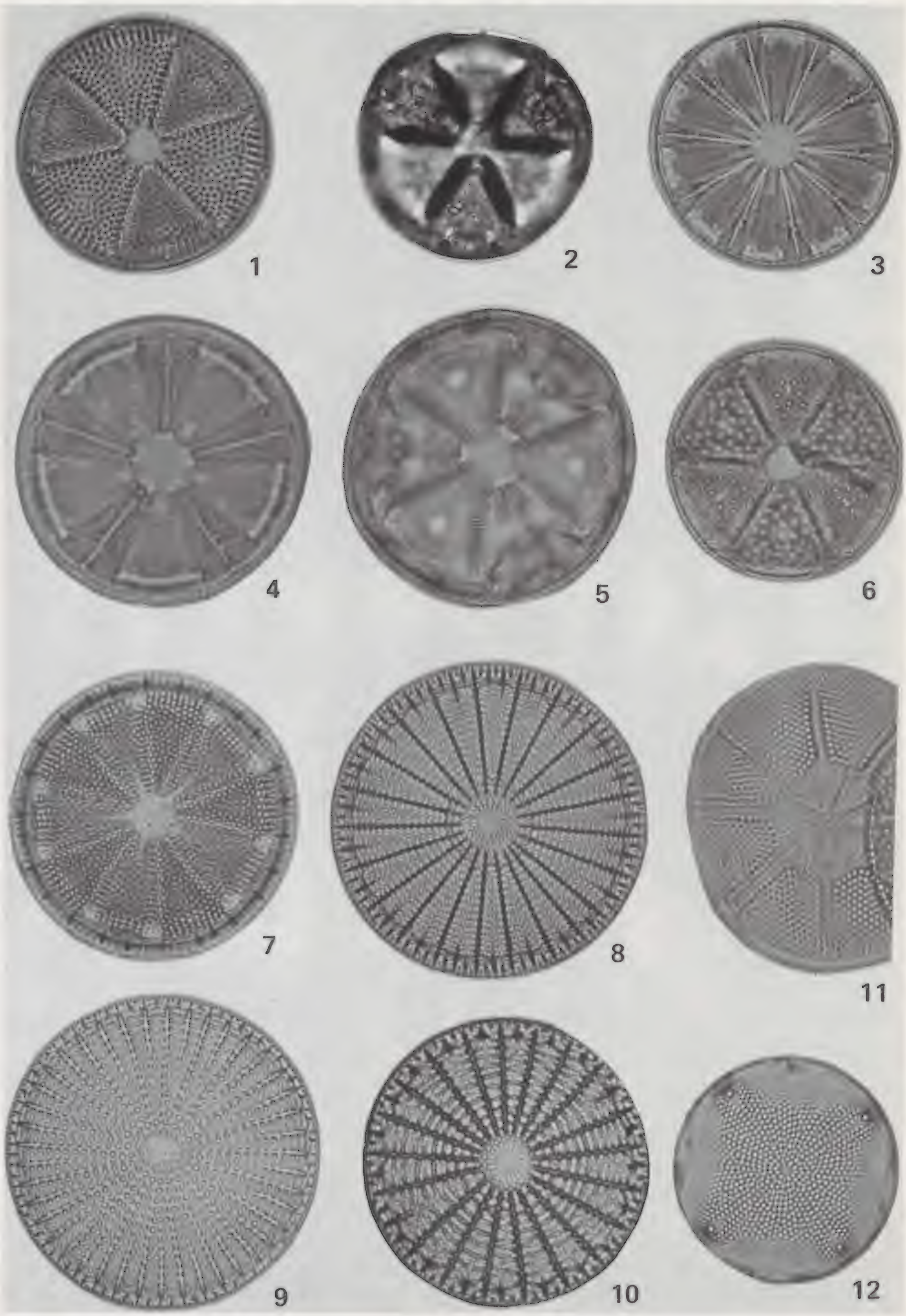


PLATE 2

Denticula dimorpha SCHRADER, 1973b, p. 418, pl. 1, fig. 16-17 (with description)
Denticulopsis dimorpha (Schrader) SIMONSEN, 1979, p. 64

DENTICULOPSIS HUSTEDTII
(Simonsen and Kanaya) Simonsen
Pl. 6, fig. 9

Denticula hustedtii SIMONSEN and KANAYA, 1961, p. 501, pl. 1, fig. 19-25; BARRON, 1975, p. 138, pl. 8, fig. 9, 10
Denticulopsis hustedtii (Simonsen and Kanaya) SIMONSEN, 1979, p. 64

DENTICULOPSIS HYALINA (Schrader)
Simonsen
Pl. 6, fig. 10

Denticula hyalina SCHRADER, 1973b, p. 418, pl. 1, fig. 22
Denticulopsis hyalina (Schrader) SIMONSEN, 1979, p. 64

DENTICULOPSIS KAMTSCHATICA (Sabelina)
Simonsen
Pl. 6, fig. 11

Denticula kamtschatica SABELINA, 1934, p. 16, 19, fig. 7-9; SCHRADER, 1973b, p. 418, pl. 1, fig. 7-8 (with description)
Denticulopsis kamtschatica (Sabelina) SIMONSEN, 1979, p. 64

DENTICULOPSIS SEMINAE (Simonsen and Kanaya) var. FOSSILIS (Schrader)
Simonsen
Pl. 6, fig. 12

Denticula seminae var. *fossilis* SCHRADER, 1973b, p. 420, pl. 1, fig. 5-6 (with description)
Denticulopsis seminae var. *fossilis* (Schrader) SIMONSEN, 1979, p. 64

Genus DIMEROGRAMMA Ralfs, 1861

DIMEROGRAMMA sp.?
Pl. 6, fig. 13

Dimerogramma sp.? BARRON, 1975, p. 139, pl. 8, fig. 13

Genus DIPLONEIS Ehrenberg, 1854

DIPLONEIS CRABRO (Ehrenberg)
Ehrenberg
Pl. 6, fig. 14

Pinnularia crabro EHRENBERG, 1844, p. 85
Diploneis crabro (Ehrenberg) EHRENBERG, 1854, pl. 19, fig. 29; BARRON, 1975, p. 139, pl. 8, fig. 18

Genus DOSSETIA Azpeitia, 1911

DOSSETIA LACERA (Forti) Hanna
Pl. 6, fig. 15

Xanthiopyxis lacera Forti *in* TEMPÈRE and PERAGALLO, 1910, p. 197
Dossetia lacera (Forti) HANNA, 1932, p. 190, pl. 11, fig. 3; BARRON, 1975, p. 140, pl. 8, fig. 23

Genus ENDICTYA Ehrenberg, 1845

ENDICTYA OCEANICA Ehrenberg
Pl. 6, fig. 16

Endictya oceanica EHRENBERG, 1845, p. 76; BARRON, 1975, p. 141, pl. 8, fig. 21

PLATE 3

1. *Aulacodiscus kittoni* Arnott. 73, +28 microns, x800.
2. *Aulacodiscus margaritaceus* Ralfs. 44, +28 microns, x400.
3. *Aulacodiscus simplex* Rattray. 48, +28 microns, x250.
4. *Auliscus caelatus* Bailey. 64, +28 microns, x600.
5. *Auliscus caelatus* Bailey var. *constricta* Rattray. 52, +28 microns, x250.
6. *Auliscus punctatus* Bailey. 43, +28 microns, x250.
7. *Bacteriastrum* sp. 73, -28 microns, x160.
8. *Biddulphia aurita* (Lyngbye) Brébisson and Godey. 60, -28 microns, x1250.
9. *Biddulphia aurita* (Lyngbye) Brébisson and Godey var. *obtusa* (Kutzing) Hustedt. 44, +28 microns, x 300.
10. *Biddulphia rhombus* (Ehrenberg) Wm. Smith. 42, +28 microns, x300.
11. *Biddulphia suborbicularis* Grunow. 39, +28 microns, x1000.
12-13. *Biddulphia tridens* (Ehrenberg) Ehrenberg. 39, +28 microns, x400.
14. *Cestodiscus pulchellus* Greville var. *maculatus* Kolbe. 64, +28 microns, x400.
15. *Chaetoceros cinctus* (spore) Gran. 58, -28 microns, x1000, 35 mm.
16. *Chaetoceros diadema* (spore) (Ehrenberg) Gran. 73, -28 microns, x1000.
17. *Chaetoceros dicladia* (spore) Castracane. 73, +28 microns, x400.

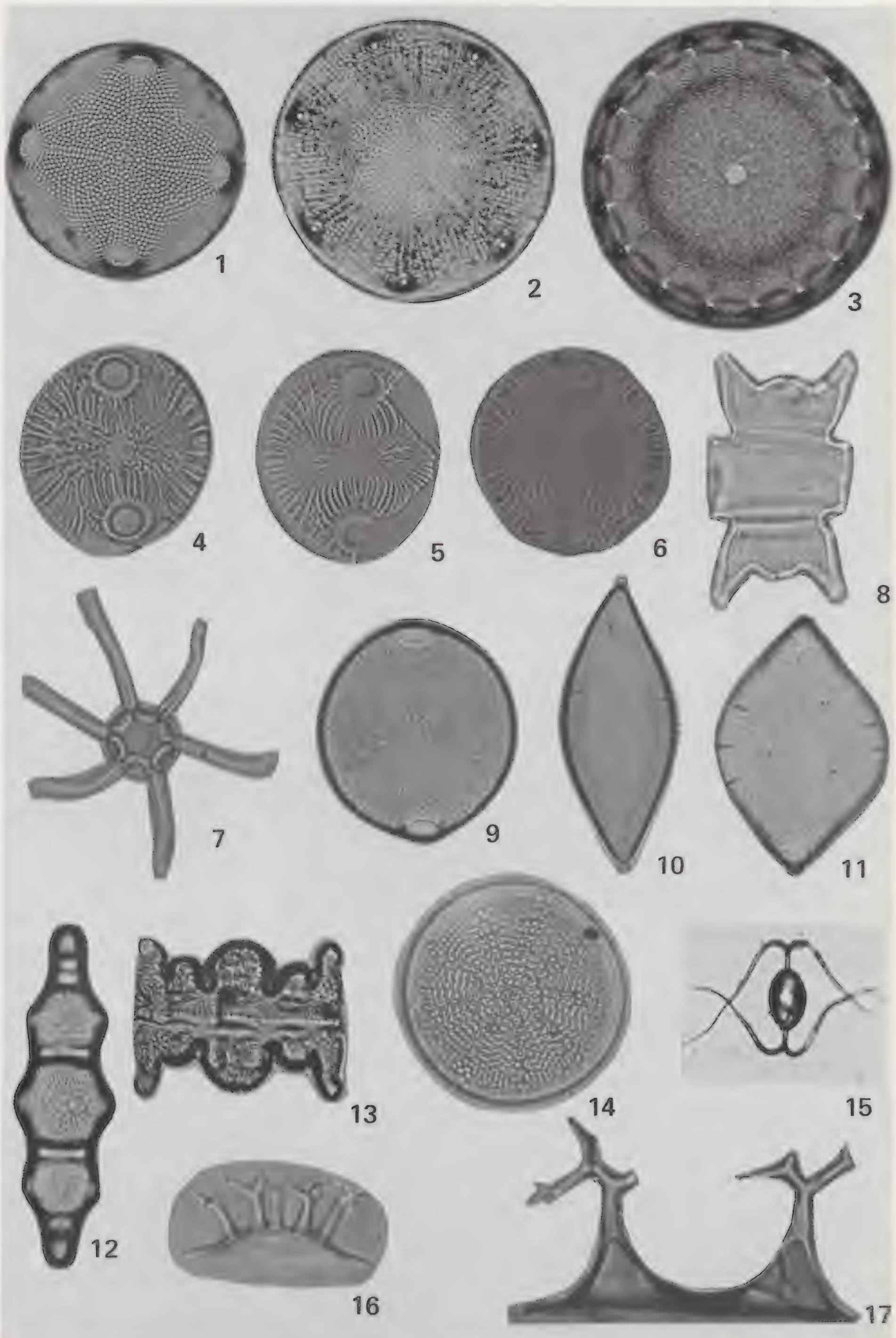


PLATE 3

ENDICTYA ROBUSTA
(Greville) Hanna and Grant
Pl. 6, fig. 17

Endictya robustus (Greville) HANNA and GRANT, 1926, p. 144, pl. 16, fig. 2-3; BARRON, 1975, p. 141, pl. 8, fig. 22

Genus ENTOPYLA Ehrenberg, 1841

ENTOPYLA AUSTRALIS var. GIGANTEA (Greville) Fricke
Pl. 6, fig. 18

Entopyla australis var. *gigantea* (Greville) Fricke, 1902, *in* Schmidt *et al.*, pl. 230, fig. 1-11, *fide* BARRON, 1975, p. 141, pl. 8, fig. 24

Genus GLYPHODESMUS Greville, 1862

GLYPHODESMUS WILLIAMSONII (Wm. Smith) Grunow
Pl. 6, fig. 19

Himantidium williamsonii WM. SMITH, 1856, p. 14, pl. 33, fig. 287
Glyphodesmus williamsonii (Wm. Smith) Grunow *in* VAN HEURCK, 1881, pl. 36, fig. 14; BARRON, 1975, p. 142, pl. 9, fig. 4

Genus GLYPHODISCUS Greville, 1862

GLYPHODISCUS STELLATUS Greville
Pl. 6, fig. 20

Glyphodiscus stellatus GREVILLE, 1862, p. 91, pl. 9, fig. 5; BARRON, 1975, p. 142, pl. 9, fig. 5

Genus GRAMMATOPHORA Ehrenberg, 1840

GRAMMATOPHORA ANGULOSA Ehrenberg
Pl. 6, fig. 21

Grammatophora angulosa EHRENBERG, 1840, p. 73; BARRON, 1975, p. 142, pl. 9, fig. 10

GRAMMATOPHORA MERLETTA
Hanna and Grant
Pl. 6, fig. 22

Grammatophora merletta HANNA and GRANT, 1926, p. 146, pl. 16, fig. 11, 12, 14 (with description); BARRON, 1975, p. 143, pl. 9, fig. 11

Genus HEMIAULUS Ehrenberg, 1845

HEMIAULUS POLYMORPHUS Grunow
Pl. 7, fig. 1

Hemiaulus polymorphus GRUNOW, 1884, p. 14, fig. 66; BARRON, 1975, p. 143, pl. 9, fig. 6

Genus HEMIDISCUS Wallich, 1860

HEMIDISCUS CUNEIFORMIS Wallich
Pl. 7, fig. 2

Hemidiscus cuneiformis WALLICH, 1860, p. 42, pl. 2, fig. 3-4; BARRON, 1975, p. 143, pl. 9, fig. 7, 8

Modern distribution: tropical, planktonic (Jousé *et al.*, 1969).

HEMIDISCUS SIMPLICISSIMUS
Hanna and Grant

Pl. 7, fig. 3

Hemidiscus simplicissimus HANNA and GRANT, 1926, p. 147, pl. 16, fig. 13; SCHRADER, 1973, p. 706, pl. 24, fig. 12, 13

PLATE 4

1. *Chaetoceros* sp. (spore). 73, +28 microns, x400.
2. *Cladogramma californicum* Ehrenberg. 73, -28 microns, x1000.
3. *Caldogramma dubium* Lohman. 46, -28 microns, x1000.
4. *Cocconeis costata* Gregory. 56, -28 microns, x1200, 35 mm.
5. *Cocconeis decipiens* Cleve. 73, +28 microns, x400.
6. *Cocconeis dirupta* Gregory var. *triumphis* (Hanna and Grant) Frenguelli. 43, +28 microns, x400.
7. *Coscinodiscus antiquus* (Grunow) Rattray. 46, -28 microns, x1250.
8. *Coscinodiscus asteromphalus* Ehrenberg. 60, +28 microns, x250.
9. *Coscinodiscus biradiatus* Greville. 39, -28 microns, x1000.
10. *Coscinodiscus excentricus* Ehrenberg var. *leasareolatus* Kanaya. 54, -28 microns, x1200.
11. *Coscinodiscus hirosakiensis* Kanaya. 61, +28 microns, x500.
12. *Coscinodiscus kurzii* Grunow. 39, +28 microns, x250.

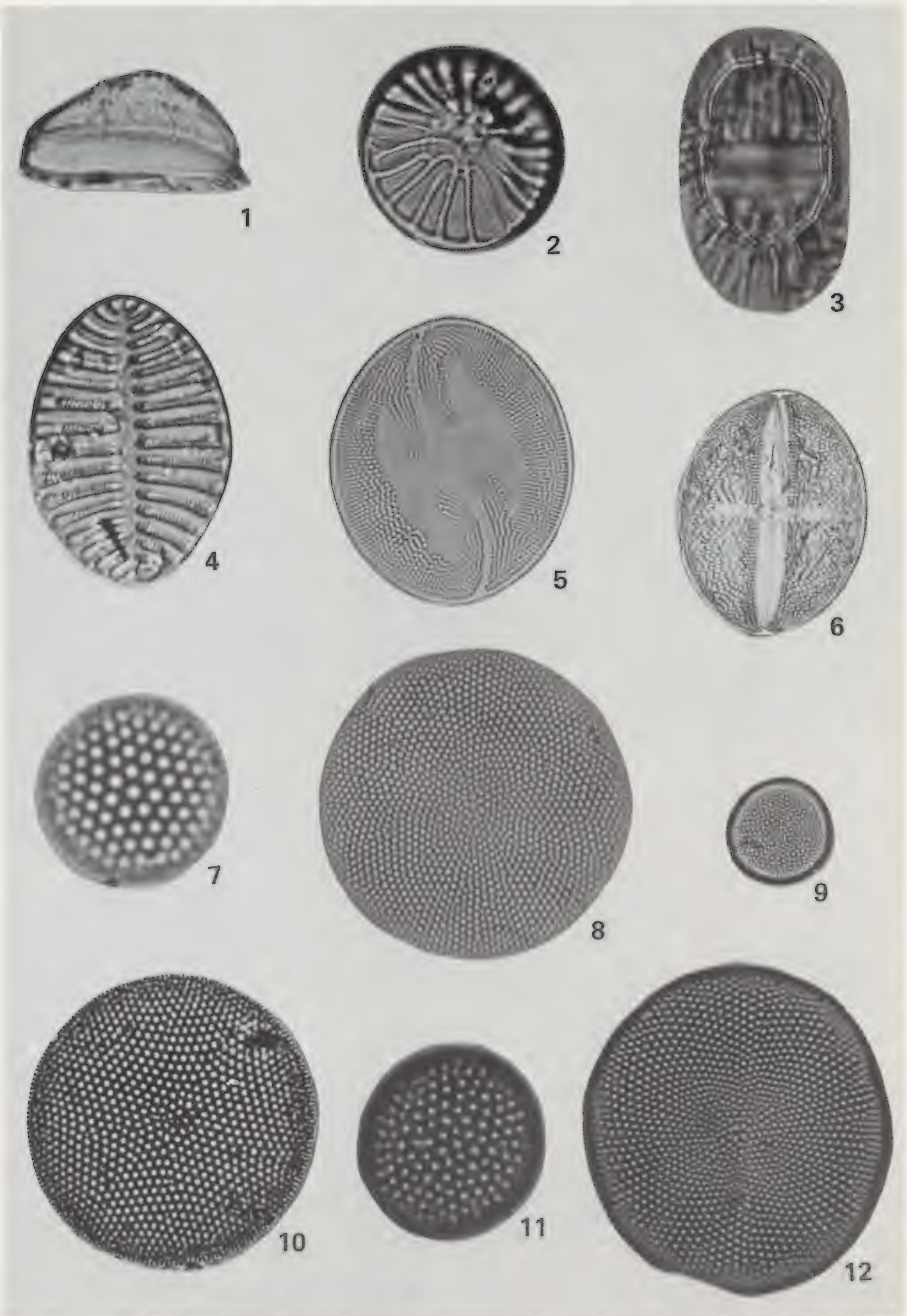


PLATE 4

Genus HERCOTHECA Ehrenberg, 1844

HERCOTHECA MAMILLARIS Ehrenberg
Pl. 7, fig. 4

Hercotheca mamillaris EHRENBERG, 1844 (1845), p. 269; EHRENBERG, 1854, pl. 33, fig. 18; BARRON, 1975, p. 143, pl. 9, fig. 13

Genus LITHODESMIUM Ehrenberg, 1840

LITHODESMIUM ASKETOGONIUM Barron
Pl. 7, fig. 5

Lithodesmium asketogonium BARRON, 1975, p. 145, pl. 9, fig. 20; pl. 10, fig. 1, 2 (with description and discussion)

LITHODESMIUM CORNIGERUM Brun
Pl. 7, fig. 6

Lithodesmium cornigerum BRUN, 1896, p. 239, pl. 24, fig. 15-17; WORNARDT, 1967, p. 67, fig. 131

LITHODESMIUM MINUSCULUM Grunow
Pl. 7, fig. 7

Lithodesmium minusculum Grunow *in* VAN HEURCK, 1883, pl. 116, fig. 1-5; BARRON, 1975, p. 145, pl. 10, fig. 4

Genus MELOSIRA Agardh, 1824

MELOSIRA CLAVIGERA Grunow
Pl. 7, fig. 8

Melosira clavigera Grunow *in* VAN HEURCK, 1882, pl. 91, fig. 1, 2; BARRON, 1975, p. 146, pl. 10, fig. 6

MELOSIRA SULCATA var. BISERIATA (Grunow) Peragallo and Peragallo (nom. cons.)
Pl. 7, fig. 9

Paralia sulcata var. *biseriata* GRUNOW, 1884, p. 92, fig. 42

Melosira sulcata var. *biseriata* (Grunow) PERAGALLO and PERAGALLO, 1897-1908, p. 448, pl. 119, fig. 14; BARRON, 1975, p. 146, pl. 10, fig. 7

MELOSIRA SULCATA var. CORONATA (Ehrenberg) Grunow (nom. cons.)
Pl. 7, fig. 10

Melosira sulcata var. *coronata* (Ehrenberg) Grunow *in* Van Heurck, 1882, pl. 91, fig. 17, *fide* BARRON, 1975, p. 146, pl. 10, fig. 20

MELOSIRA SULCATA var. SIBERICA Grunow (nom. cons.)
Pl. 7, fig. 11

Melosira sulcata var. *siberica* Grunow *in* VAN HEURCK, 1882, pl. 91, fig. 22; BARRON, 1975, p. 146, pl. 10, fig. 13

Genus MUELLERIELLA Van Heurck, 1896

MUELLERIELLA LIMBATA (Ehrenberg) Van Heurck
Pl. 7, fig. 12

Muelleriella limbata (Ehrenberg) VAN HEURCK, 1896, p. 435, fig. 160; BARRON, 1975, p. 147, pl. 10, fig. 9

Genus NAVICULA Bory, 1824

NAVICULA LYRA var. EHRENBERGII Cleve
Pl. 7, fig. 13

Navicula lyra Ehrenberg var. *ehrenbergii* CLEVE, 1895, p. 63, BARRON, 1975, p. 148, pl. 10, fig. 19

NAVICULA OPTIMA Hanna
Pl. 7, fig. 14

Navicula optima HANNA, 1932, p. 202, pl. 13, fig. 6 (with description); BARRON, 1975, p. 148, pl. 10, fig. 14

PLATE 5

1. *Coscinodiscus marginatus* Ehrenberg. 71, +28 microns, x400.
2. *Coscinodiscus nitidus* (Gregory). 42, +28 microns, x540.
3. *Coscinodiscus monicae* (Grunow) Rattray. 48, -28 microns, x1000.
4. *Coscinodiscus nodulifer* Schmidt. 39, +28 microns, x540.
5. *Coscinodiscus pilosus* Schmidt. 39, +29 microns, x400.
6. *Coscinodiscus obscurus* Schmidt. 42, +63 microns, x400, 35 mm.
7. *Coscinodiscus oculusiridis* Ehrenberg var. *borealis* (Bailey) Cleve. 70, +63 microns, x400.
8. *Coscinodiscus oculusiridis (oculus-iridis)* Ehrenberg var. *oculusiridis* Barron 73, +63 microns, x400, 35 mm.
9. *Coscinodiscus plicatus* Grunow. 65, -28 microns, x1000.

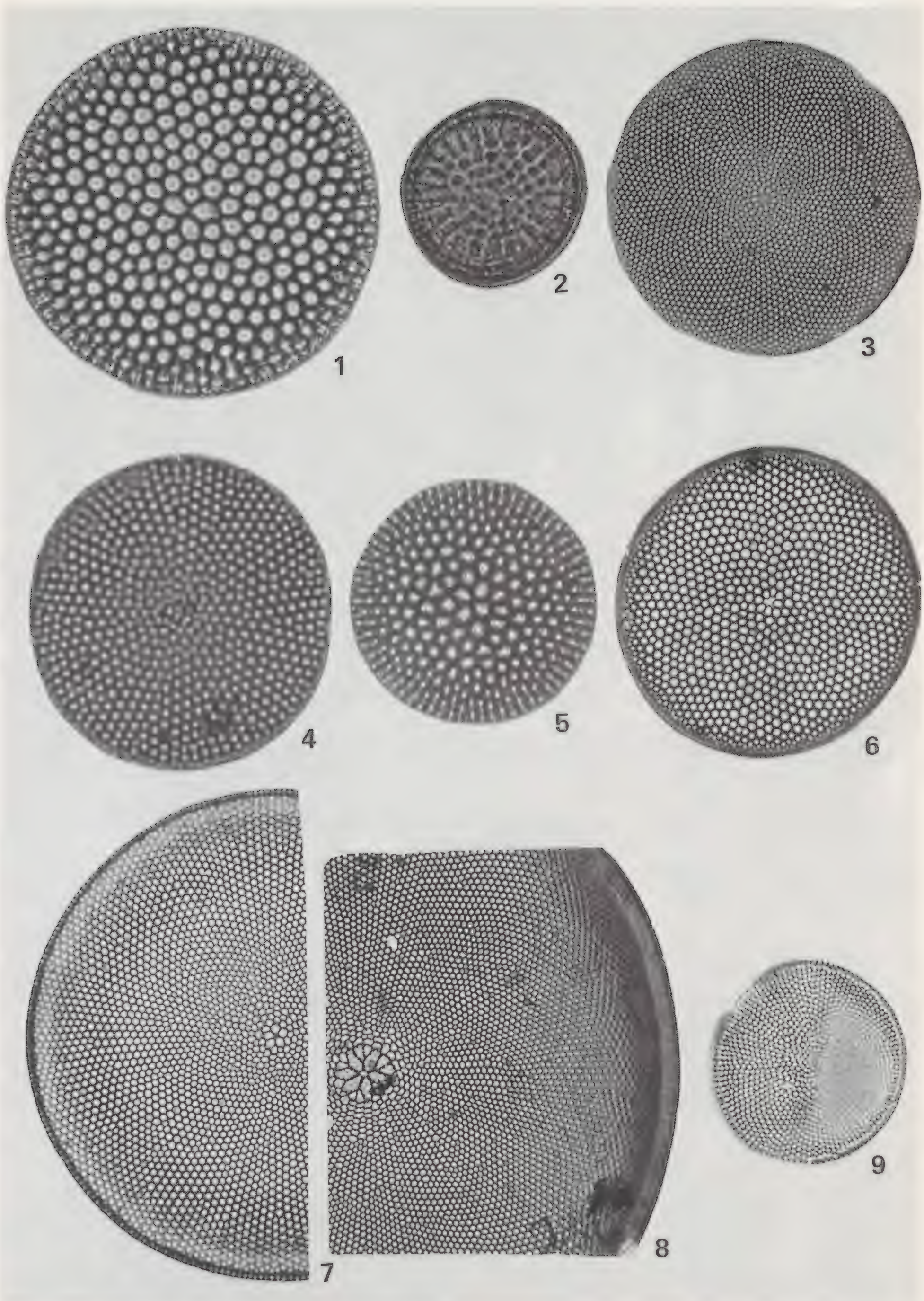


PLATE 5

Genus NITZSCHIA Hassal, 1845

NITZSCHIA CALIFORNICA Schrader
Pl. 8, fig. 1

Nitzschia californica SCHRADER, 1973, p. 707, pl. 5, fig. 15; pl. 26, fig. 6 (with description)

NITZSCHIA FOSSILIS (Frenguelli) emend. Kanaya
Pl. 8, fig. 2

Nitzschia fossilis (Frenguelli) emend. Kanaya *in* Kanaya and Koizumi, 1970, *fide* BARRON, 1975, p. 149, pl. 11, fig. 8

NITZSCHIA JOUSEAE Burckle
Pl. 8, fig. 3

Nitzschia jouseae BURCKLE, 1972, p. 240, pl. 2, fig. 17-20 (with description); SCHRADER, 1973, p. 707, pl. 4, fig. 20, 21, 22, 23

NITZSCHIA MIOCENICA Burckle
Pl. 8, fig. 4

Nitzschia miocenica BURCKLE, 1972, p. 240, pl. 2, fig. 10- 15 (with description)

NITZSCHIA REINHOLDII Kanaya
Pl. 8, fig. 5

Nitzschia reinholdii Kanaya, 1970, *in* KANAYA and KOIZUMI, 1970, p. 58; SCHRADER, 1973, p. 708, pl. 4, fig. 12-16; pl. 5, fig. 1-9 (with description)

NITZSCHIA ROLANDII Schrader
Pl. 8, fig. 6

Nitzschia rolandii SCHRADER, 1973, p. 708, pl. 5, fig. 31; pl. 26, fig. 3, 4 (with description); BARRON, 1975, p. 150, pl. 11, fig. 5, 7

Genus OPEPHORA Petit, 1888

OPEPHORA SCHWARTZII (Grunow) Petit
Pl. 8, fig. 7

Opephora schwartzii (Gruno) Petit *in* Pelletan, 1889, *fide* BARRON, 1975, p. 150, pl. 11, fig. 10

Genus PERIPTERA Ehrenberg, 1845

PLATE 6

1. *Rossiella praepaleaceus* (Schrader) Gersonde and Schrader. 43, -28 microns, x1000, 35 mm.
2. *Coscinodiscus radiatus* Ehrenberg. 70, +63 microns, x580, 35 mm.
3. *Coscinodiscus robustus* Greville var. *incretus* Schmidt, Wornardt. 39, +28 microns, x250.
4. *Coscinodiscus stellaris* Roper var. *symbolophora* (Grunow) Jørgensen. 56, -28 microns, x1000, 35 mm.
5. *Coscinodiscus subtilis* Ehrenberg. 47, +63 microns, x600.
6. *Coscinodiscus tabularis* Grunow var. *egregius* (Rattray) Hustedt. 42, -28 microns, x1000.
7. *Coscinodiscus vetustissimus* Pantocsek. 39, +28 microns, x1000, 35 mm.
8. *Denticulopsis dimorpha* (Schrader) Simonsen. 42, -28 microns, x1350.
9. *Denticulopsis hustedtii* (Simsonsen and Kanaya) Simonsen. 44, -28 microns, x1500.
10. *Denticulopsis hyalina* (Schrader) Simsonsen. 60, -28 microns, x1950.
11. *Denticulopsis kamtschatica* (Zabelina) Simonsen. 49, -28 microns, x1500.
12. *Denticulpsis seminae* (Simonsen and Kanaya) var. *fossilis* (Schrader) Simonsen. 60, -28 microns, x1250.
13. *Dimerogramma* sp.? 42, -28 microns, x1000.
14. *Diploneis crabro* (Ehrenberg). 46, -28 microns, x1000, 35 mm.
15. *Dossetia lacera* (Forti) (spore) Hanna. 64, +28 microns, x640.
16. *Endictya oceanica* Ehrenberg. 73, -28 microns, x1000, 35 mm.
17. *Endictya robusta* (Greville) Hanna and Grant. 54, +63 microns, x250.
18. *Entopyla australis* var. *gigantea* (Greville) Fricke. 67, +28 microns, x400.
19. *Glyphodesmus williamsonii* (Wm. Smith) Grunow. 42, -28 microns, x1000, 35 mm.
20. *Glyphodiscus stellatus* Greville. 56, +28 microns, x640.
21. *Grammatophora angulosa* Ehrenberg. 73, -28 microns, x1200.
22. *Grammatophora merletta* Hanna and Grant. 73, -28 microns, x1000.

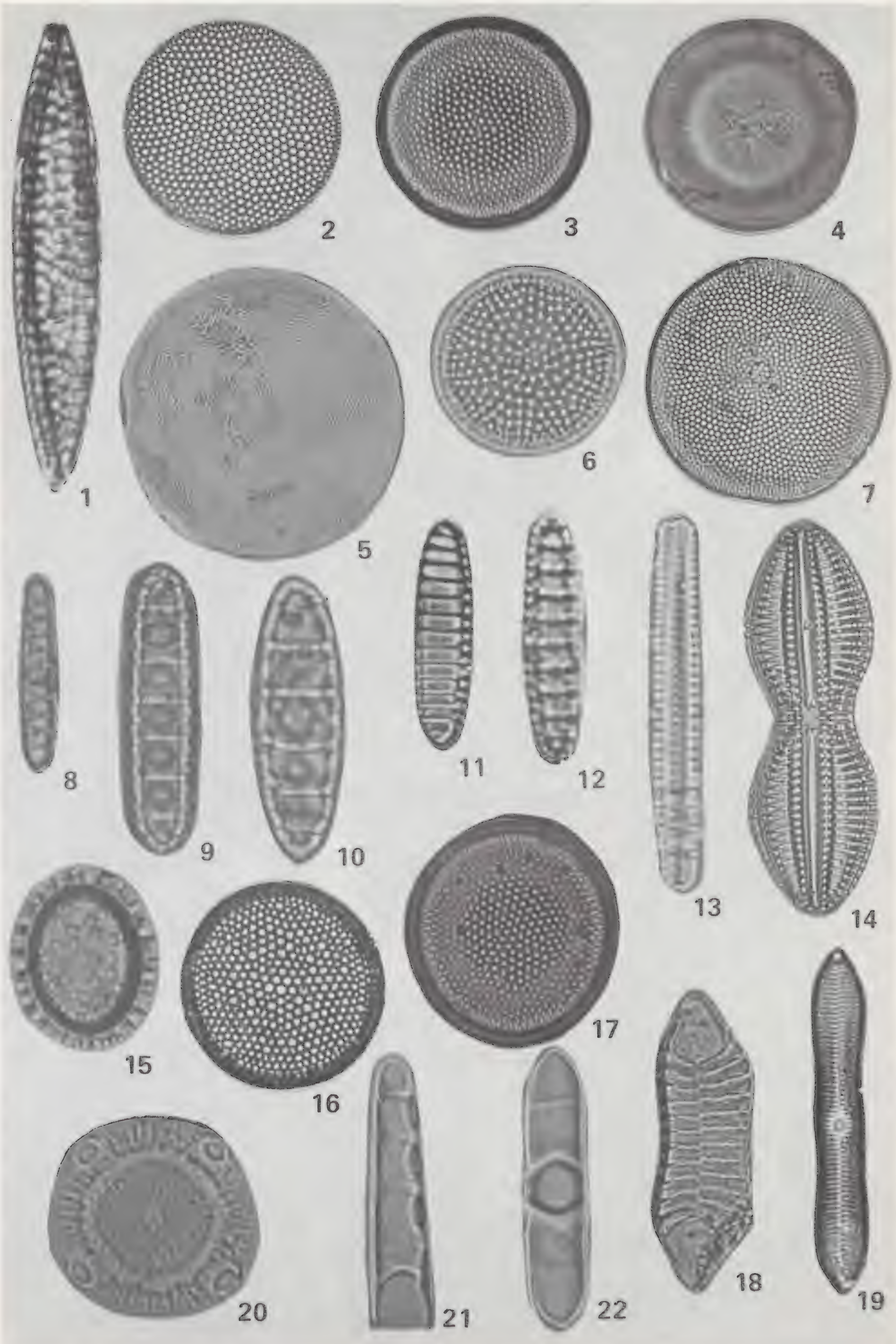


PLATE 6

PERIPTERA TETRACLADIA? Ehrenberg
(resting spore)
Pl. 8, fig. 8

Periptera tetracladia EHRENBERG, 1845, p. 270; HANNA, 1932, p. 205, pl. 13, fig. 8; BARRON, 1975, p. 150

Genus POROSIRA Jørgensen, 1905

POROSIRA GLACIALIS (Grunow) Jørgensen
Pl. 8, fig. 9

Podosira hormoidesi var. *glacialis* GRUNOW, 1884, p. 108, pl. 5, fig. 32
Porosira glacialis (Grunow) JØRGENSEN, 1905, p. 97, pl. 6, fig. 7; KOIZUMI, 1973, pl. 4, fig. 17, 18

Genus PSEUDOEUNOTIA Grunow, 1865

PSEUDOEUNOTIA DOLIOLUS (Wallich) Grunow
Pl. 8, fig. 10

Synedra doliolus WALLICH, 1860, p. 48, pl. 2, fig. 19
Pseudoeunotia doliolus (Wallich) Grunow *in* VAN HEURCK, 1881, pl. 35, fig. 22; SCHRADER, 1973a, p. 709, pl. 9, fig. 1-5, 10, 12, 22, 23; pl. 10, fig. 24, 29

Genus PSEUDOPYXILLA Forti, 1909

PSEUDOPYXILLA AMERICANA (Ehrenberg) Forti
Pl. 8, fig. 11

Rhizosolenia americana EHRENBERG, 1841 (1843), p. 422
Pseudopyxilla americana (Ehrenberg) FORTI, 1909, p. 28, 30, pl. 1, fig. 6, 7; BARRON, 1975, p. 151, 152, pl. 11, fig. 12

PSEUDOPYXILLA DUBIA (Grunow) Forti
Pl. 8, fig. 12

Pyxilla dubia Grunow *in* VAN HEURCK, 1882, pl. 83, fig. 7, 8, pl. 83b, fig. 12
Pseudopyxilla dubia (Grunow) FORTI, 1909, p. 28, pl. 1, fig. 22; BARRON, 1975, p. 152, pl. 11, fig. 13

Genus RHABDONEMA Kützing, 1844

RHABDONEMA JAPONICUM Tempère
var. SPARSICOSTATUM Tempère and Brun
Pl. 8, fig. 13

Rhabdonema japonicum Tempère var. *sparsicostatum* TEMPÈRE and BRUN, 1889, p. 53; BARRON, 1975, p. 152, pl. 11, fig. 16

Genus RHAPHONEIS Ehrenberg, 1844

RHAPHONEIS AMPHICEROS Ehrenberg
var. ELONGATA Peragallo and Peragallo
Pl. 8, fig. 16

Rhaphoneis amphiceros Ehrenberg var. *elongata* PERAGALLO and PERAGALLO, 1901, pl. 83, fig. 10; BARRON, 1975, p. 152, pl. 12, fig. 1

RHAPHONEIS AMPHICEROS (Ehrenberg) var.
GEMMIFERA Peragallo and Peragallo
Pl. 8, fig. 17

Rhaphoneis amphiceros (Ehrenberg) var. *gemmifera* PERAGALLO and PERAGALLO, 1901, pl. 83, fig. 11-14; BARRON, 1975, p. 152, pl. 12, fig. 2

RHAPHONEIS FATULA Lohman
Pl. 8, fig. 14

Rhaphoneis fatula LOHMAN, 1938, p. 93, pl. 22, fig. 5; ANDREWS, 1975, p. 213, pl. 3, fig. 38 (with description)

PLATE 7

1. *Hemiaulus polymorphus* Grunow. 42, -28 microns, x1100, 35 mm.
2. *Hemidiscus cuneiformis* Wallich. 43, +28 microns, x520, 35 mm.
3. *Hemidiscus simplicissimus* Hanna and Grant. 46, -28 microns, x1000.
4. *Hercotheca mamillaris* Ehrenberg. 73, -28 microns, x1000.
5. *Lithodesmium asketogonium* Barron. 43, +28 microns, x600.
6. *Lithodesmium cornigerum* Brun. 60, +28 microns, x400.
7. *Lithodesmium minusculum* Grunow. 54, -28 microns, x1600.
8. *Melosira clavigera* Grunow. 39, +28 microns, x315.
9. *Melosira sulcata* var. *biseriata* (Grunow) Pergallo and Pergallo. 73, -28 microns, x1000.
10. *Melosira sulcata* var. *coronata* (Ehrenberg) Grunow. 73, -28 microns, x1300.
11. *Melosira sulcata* var. *siberica* Grunow. 73, -28 microns, x1300.
12. *Muelleriella limbata* (Ehrenberg) Van Heurck. 73, +28 microns, x520.
13. *Navicula lyra* var. *ehrenbergii* Cleve. 52, +28 microns, x400.
14. *Navicula optima* Hanna. 60, -28 microns, x1600.

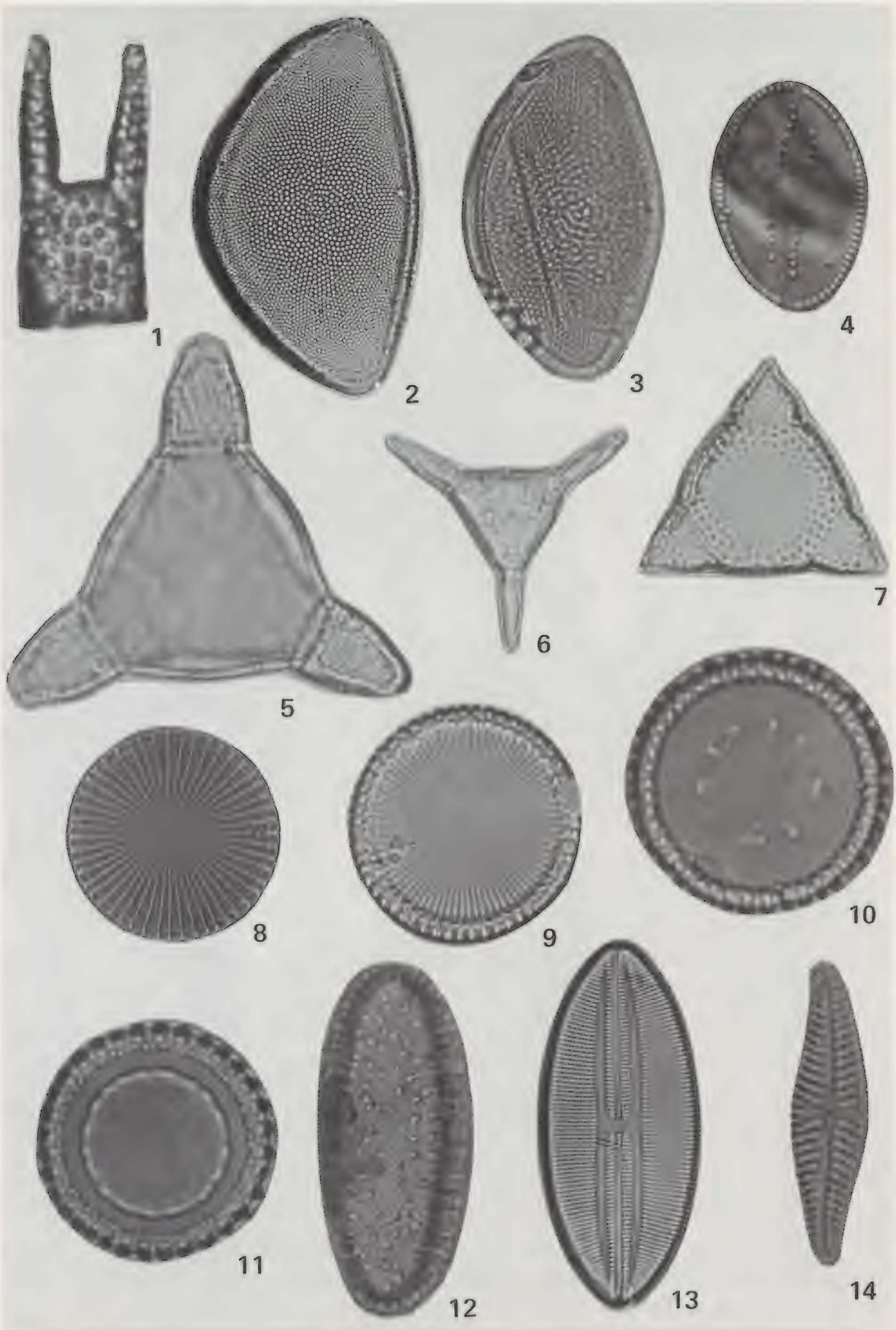


PLATE 7

RHAPHONEIS SACHALINENSIS
Sheshukova-Poretzkaya
Pl. 8, fig. 15

Rhaphoneis sachalinensis SHESHUKOVA-PORETZKAYA, 1967, p. 242, pl. 42, fig. 2 (with description); BARRON, 1975, p. 153, pl. 12, fig. 3

Genus RHIZOSOLENIA Brightwell, 1858

RHIZOSOLENIA cf. R. ALATA
Brightwell, Schrader
Pl. 8, fig. 18

Rhizosolenia cf. *R. alata* Brightwell, SCHRADER, 1973a, p. 709, pl. 10, fig. 14-17, 23 (with discussion)

RHIZOSOLENIA BARBOI (Brun)
Tempère and Peragallo
Pl. 9, fig. 1

Pyxilla barboi BRUN, 1894, p. 87, pl. 5, fig. 16, 17, 23
Rhizosolenia barboi (Brun) TEMPÈRE and PERAGALLO, 1908, p. 26, no. 47; SCHRADER, 1973a, p. 709, pl. 24, fig. 4, 7

RHIZOSOLENIA HEBETATA Bailey
forma HIEMALIS Gran
Pl. 9, fig. 2

Rhizosolenia hebetata Bailey forma *hiemalis* GRAN, 1904, p. 527, pl. 27, fig. 9; KOIZUMI, 1973, p. 844, pl. 5, fig. 34, 35

RHIZOSOLENIA PRAEBERGONII Muchina
Pl. 9, fig. 3

Rhizosolenia praebergonii MUCHINA, 1965, p. 24, pl. 2, fig. 3, 4; KOIZUMI, 1968, p. 217, pl. 34, fig. 20a-21b

RHIZOSOLENIA STYLIFORMIS Brightwell
Pl. 9, fig. 4

Rhizosolenia styliformis BRIGHTWELL, 1858, p. 95, pl. 5, fig. 5a, b, d; BARRON, 1975, p. 153, pl. 12, fig. 6

Genus ROSSIELLA
Desikachary and Maheshwari, 1958

ROSSIELLA PRAEPALEACEA (Schrader)
Gersonde and Schrader
Pl. 6, fig. 1

Coscinodiscus praepaleacea SCHRADER, 1973, p. 703, pl. 3, fig. 1-9
Cussia praepaleacea SCHRADER, 1974, p. 543, fig. 1, 8.
Rossiella praepaleacea (Schrader) GERSONDE and SCHRADER, 1984, p. 104, pl. 1, fig. 11, 12

Genus ROUXIA Brun and Heribaud, 1893

ROUXIA CALIFORNICA Peragallo
Pl. 9, fig. 5

Rouxia californica Peragallo *in* TEMPÉRE and PERAGALLO, 1910, p. 245, no. 468-469; BARRON, 1975, p. 154, pl. 12, fig. 11

PLATE 8

1. *Nitzschia californica* Schrader. 73, -28 microns, x1000.
2. *Nitzschia fossilis* (Frenguelli) emend. Kanaya. 42, -28 microns, x1000.
3. *Nitzschia jouseae* Burckle. 66, -28 microns, x2750, 35 mm.
4. *Nitzshia miocenica* Burckle. 55, -28 microns, x1200, 35 mm.
5. *Nitzschia reinholdii* Kanaya. 52, -28 microns, x1200.
6. *Nitzschia rolandii* Schrader. 43, -28 microns, x1600.
7. *Opephora schwartzii* (Grunow) Petit. 44, -28 microns, x1000.
8. *Periptera tetracladia*? (spore) Ehrenberg. 67, -28 microns, x1000, 35 mm.
9. *Porosira glacialis* (Grunow) Jørgensen. 54, +28 microns, x1200.
10. *Pseudoeunotia doliolus* (Wallich) Grunow. 70, -28 microns, x1200.
11. *Pseudopyxilla americana* (Ehrenberg) Forti. 39, +28 microns, x520, 35 mm.
12. *Pseudopyxilla dubia* (Grunow) Forti. 54, +28 microns, x340.
13. *Rhabdonema japonicum* Tempère var. *sparsicostatum* Tempère and Brun. 73, -28 microns, x1150.
14. *Rhaphoneis fatula* Lohman. 73, -28 microns, x1000.
15. *Rhaphoneis sachalinensis* Sheshukova-Poretzkaya. 54, -28 microns, x1500.
16. *Rhaphoneis amphiceros* Ehrenberg var. *elongata* Peragallo and Peragallo. 39, +38 microns, x400, 35 mm.
17. *Rhaphoneis amphiceros* (Ehrenberg) var. *gemmifera* Peragallo and Peragallo. 73, -28 microns, x1000.
18. *Rhizosolenia* cf. *R. alata* Brightwell, Schrader. 71, +28 microns, x800.

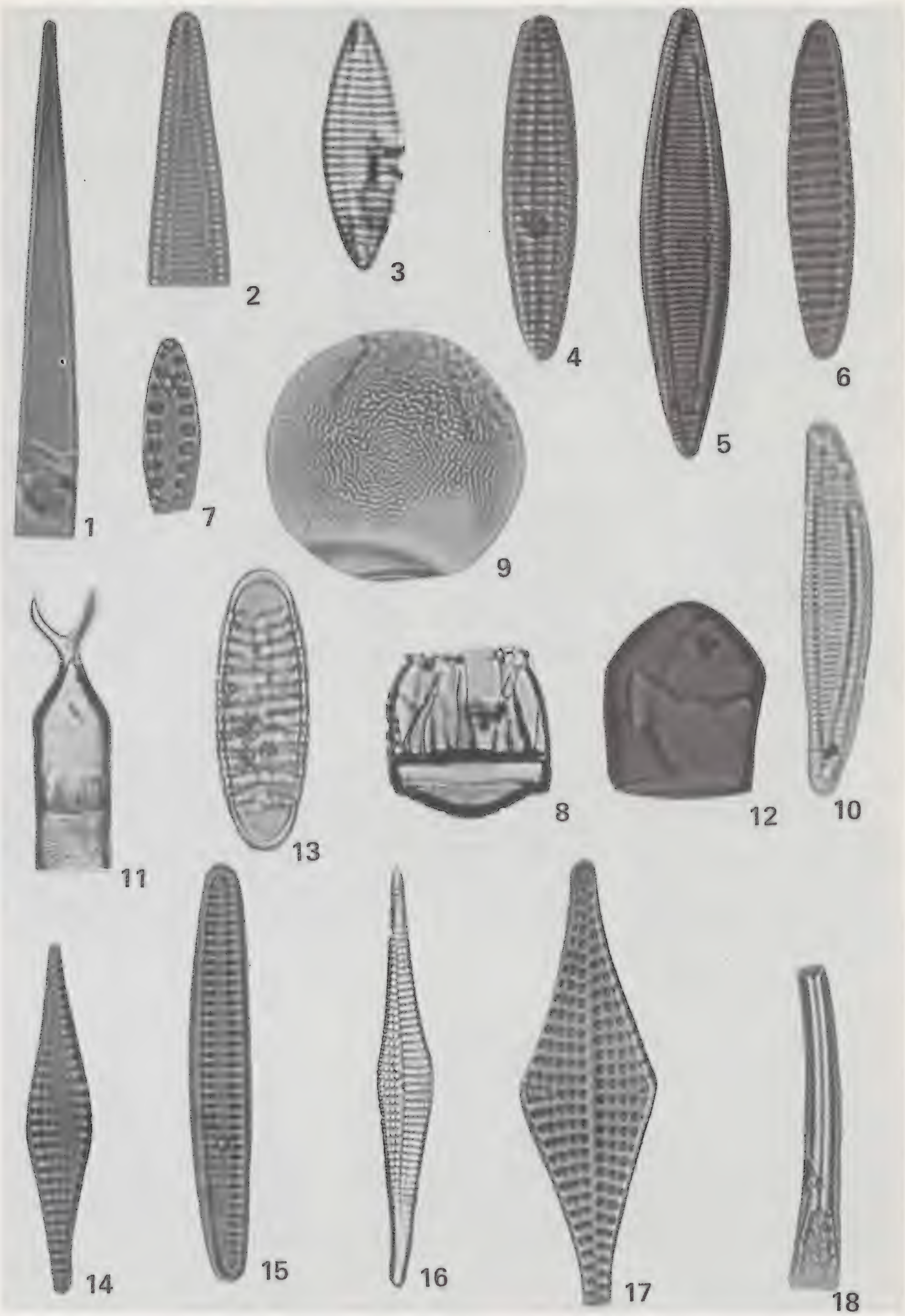


PLATE 8

ROUXIA YABEI Hanna
Pl. 9, fig. 6

Rouxia yabei HANNA, 1930, p. 185, pl. 14, fig. 2-4 (with description); BARRON, 1975, p. 154, pl. 12, fig. 7

Genus STEPHANODISCUS Ehrenberg, 1845

STEPHANODISCUS sp.
Pl. 9, fig. 7

Stephanodiscus sp. JOUSÉ, KAZARINA and MUCHINA, 1982, pl. 4, fig. 5, 6

Genus STEPHANOGONIA Ehrenberg, 1844

STEPHANOGONIA HANZAWAE Kanaya
Pl. 9, fig. 8-9

Stephanogonia hanzawae KANAYA, 1959, p. 118, pl. 11, fig. 3-7 (with description); BARRON, 1975, p. 154, pl. 12, fig. 12 (spore)

STEPHANOGONIA POLYACANTHA Forti
Pl. 9, fig. 10

Stephanogonia actinoptychus var. *polyacantha* FORTI, 1910, p. 1310, pl. 62
Stephanogonia polyacantha FORTI, 1913, p. 1560, pl. 12, fig. 11; BARRON, 1975, p. 154, pl. 12, fig. 13

Genus STEPHANOPYXIS Ehrenberg, 1844

STEPHANOPYXIS APPENDICULATA Ehrenberg
Pl. 9, fig. 11

Stephanopyxis appendiculata Ehrenberg, 1854, pl. 18, fig. 4; WORNARDT, 1967, p. 17, fig. 12, 13

STEPHANOPYXIS HORRIDUS Koizumi
Pl. 9, fig. 12-13

Stephanopyxis horridus KOIZUMI, 1972, p. 348, pl. 42, fig. 1a, 2b

STEPHANOPYXIS SPINOSSIMA Grunow
Pl. 9, fig. 14

Stephanopyxis spinossima Grunow, 1884, *fide* BARRON, 1975, p. 155, pl. 12, fig. 18

STEPHANOPYXIS TURRIS (Greville and Arnott) Ralfs
Pl. 9, fig. 15-16

Cresswellia turris GREVILLE and ARNOTT, 1857, p. 538, pl. 14, fig. 109
Stephanopyxis turris (Greville and Arnott) Ralfs *in* PRITCHARD, 1861, p. 826, pl. 5, fig. 74; BARRON, 1975, p. 155, pl. 13, fig 1-3

Genus STICTODISCUS Greville, 1861

STICTODISCUS BURYANUS Greville
Pl. 9, fig. 17

Stictodiscus buryanus GREVILLE, 1861, p. 40, pl. 4, fig. 1; BARRON, 1975, p. 156, pl. 13, fig. 5

PLATE 9

1. *Rhizosolenia barboi* (Brun) Tempère and Peragallo. 73, -28 microns, x600.
2. *Rhizosolenia hebetata* Bailey forma *hiemalis* Gran. 42, -28 microns, x1000.
3. *Rhizosolenia praebergonii* Muchina. 68, -28 microns, x1000.
4. *Rhizosolenia styliformis* Brightwell. 60, -28 microns, x1100.
5. *Rouxia californica* Peragallo. 46, -28 microns, x1200.
6. *Rouxia yabei* Hanna. 39, -28 microns, x1000.
7. *Stephanodiscus* sp. 48, +28 microns, x600.
8-9. *Stephanogonia hanzawae* Kanaya. 73, -28 microns, x1500, specimen at two different levels of focus.
10. *Stephanogonia polyacantha* Forti. 64, +28 microns, x650.
11. *Stephanopyxis appendiculata* Ehrenberg. 64, +63 microns, x280.
12-13. *Stephanopyxis horridus* Koizumi. 73, -28 microns, x1000, specimen at two different levels of focus.
14. *Stephanopyxis spinossima* Grunow. 39, +328 microns, x325.
15-16. *Stephanopyxis turris* (Greville and Arnott) Ralfs. Fig. 15, 73, +28 microns, x500. Fig. 16, 44, +28 microns, x500.
17. *Stictodiscus buryanus* (Greville). 39, +28 microns, x250.
18. *Stictodiscus californicus* Greville. 52, +63 microns, x250.

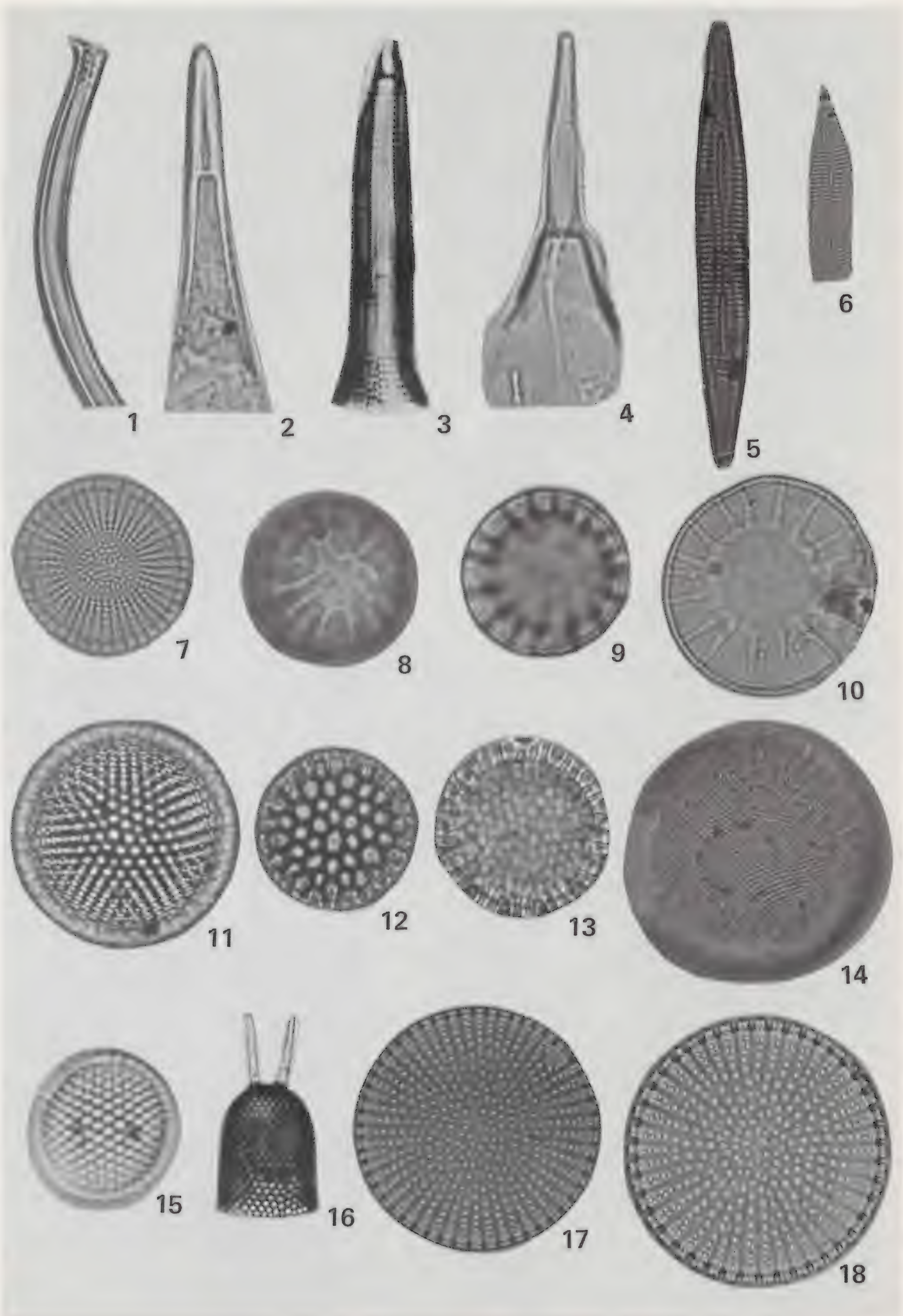


PLATE 9

STICTODISCUS CALIFORNICUS Greville
Pl. 9, fig. 18

Stictodiscus californicus GREVILLE, 1861, p. 79, pl. 10, fig. 1; WORNARDT, 1967, p. 38, fig. 54, 55

Genus SYNEDRA Ehrenberg, 1830

SYNEDRA JOUSEANA
Sheshukova-Poretzkaya
Pl. 10, fig. 1

Synedra jouseana SHESHUKOVA-PORETZKAYA, 1962, p. 208, fig. 4; SCHRADER, p. 710, pl. 23, fig. 21-23, 25, 38

Genus THALASSIONEMA Grunow, 1881

THALASSIONEMA ANTIQUA Schrader
Pl. 10, fig. 2

Thalassionema antiqua SCHRADER, 1973a, p. 711, pl. 23, fig. 26-30

THALASSIONEMA HIROSAKIENSIS (Kanaya)
Schrader
Pl. 10, fig. 3

Fragilaria hirosakiensis KANAYA, 1959, p. 104-106, pl. 9, fig. 11-15
Thalassionema hirosakiensis (Kanaya) SCHRADER, 1973, p. 711, pl. 23, fig. 31-33

THALASSIONEMA NITZSCHIOIDES (Grunow)
Van Heurck
Pl. 10, fig. 4

Synedra nitzschioides GRUNOW, 1862, p. 403, pl. 5, fig. 18
Thalassionema nitzschioides (Grunow) VAN HEURCK, 1896, p. 319, fig. 75; SCHRADER, 1973, p. 712, pl. 23, fig. 2, 6, 8

Genus THALASSIOSIRA Cleve, 1873

THALASSIOSIRA ANTIQUA (Grunow)
Cleve-Euler
Pl. 10, fig. 5

Coscinodiscus antiquus GRUNOW, 1884, p. 84, pl. 4, fig. d
Thalassiosira antiqua (Grunow) CLEVE-EULER, 1941, p. 173, fig. 4; BARRON, 1975, p. 157, pl. 13, fig. 10, 13

THALASSIOSIRA CONVEXA Muchina
Pl. 10, fig. 6

Thalassiosira convexa MUCHINA, 1965, p. 22, pl. 11, fig. 1, 2; SCHRADER, 1973, p. 712, pl. 11, fig. 37, 38

THALASSIOSIRA CONVEXA Muchina
var. ASPINOSA Schrader
Pl. 10, fig. 7

PLATE 10

1. *Synedra jouseana* Sheshukova-Poretzkaya. 48, -28 microns, x1000.
2. *Thalassionema antiqua* Schrader. 60, -28 microns, x1150.
3. *Thalassionema hirosakiensis* (Kanaya) Schrader. 57, -28 microns, x1300.
4. *Thalassionema nitzschioides* (Grunow) Van Heurck. 46, -28 microns, x1000.
5. *Thalassiosira antiqua* (Grunow) Cleve-Euler. 43, +28 microns, x0000.
6. *Thalassiosira convexa* Muchina. 60, -28 microns, x2000.
7. *Thalassiosira convexa* var. *aspinosa* Schrader. 4, -28 microns, x1500.
8. *Thalassiosira* cf. *T. decipiens* (Grunow) Jørgensen. 60, -28 microns, x1200.
9. *Thalassiosira excentrica* (Ehrenberg) Cleve. 57, +28 microns, x800.
10. *Thalassiosira gravida* Cleve forma *fossilis* Jousé. 68, +28 microns, x525.
11. *Thalassiosira hyalina* (Grunow) Gran. 60, -28 microns, x1250.
12. *Thalassiosira hyalinopsis* Barron. 59, -28 microns, x1000.
13. *Thalassiosira miocenica* Schrader. 54, -28 microns, x1000.
14. *Thalassiosira nativa* Sheshukova-Poretzkaya. 46, -28 microns, x1500.
15. *Thalassiosira nidulus* (Tempère and Brun) Jousé. 43, +28 microns, x500.

16-18. *Thalassiosira oestrupii* (Ostenfeld) Proshkina-Lavrenko. Fig. 16. 60, -28 microns, x1200. Fig. 17. 62, -28 microns, x1000. Fig. 18. 64, -28 microns, x1000.

19. *Thalassiosira* cf. *T. pacifica* Gran and Angst. 57, +28 microns, x400.
20. *Thalassiosira praeconvexa* Burckle. 43, -28 microns, x650.
21. *Thalassiosira punctata* Jousé. 59, +28 microns, x650.

22-23. *Thalassiosira zabelinae* Jousé. 73, -28 microns, x1000, specimen at two different levels of focus.

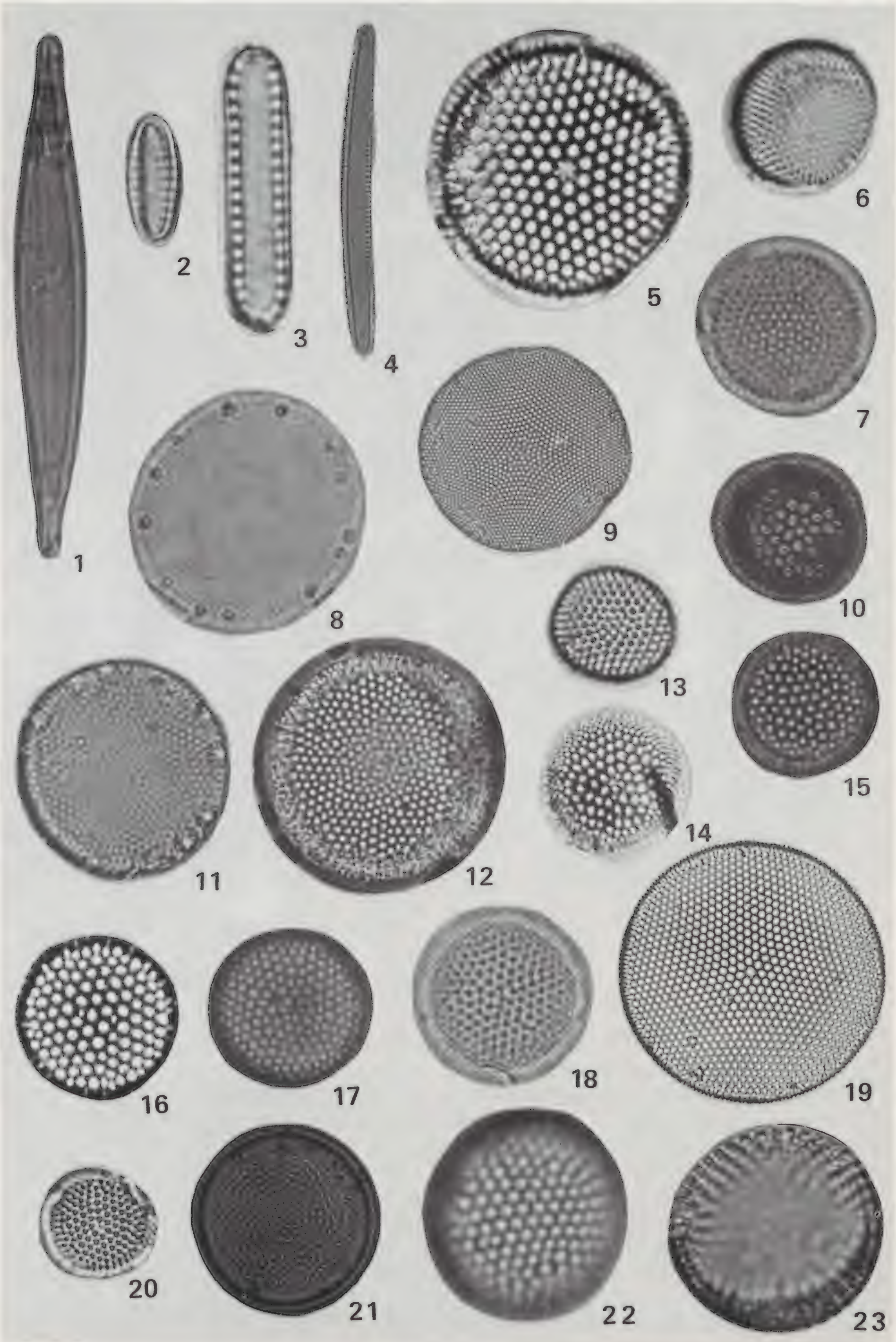


PLATE 10

Thalassiosira convexa var. *aspinosa* SCHRADER, 1974b, p. 916, pl. 2, fig. 8, 9, 13a-21

THALASSIOSIRA cf. T. DECIPIENS (Grunow) Jørgensen
Pl. 10, fig. 8

Coscinodiscus excentricus var. *decipiens* GRUNOW, 1878, p. 125, pl. 4, fig. 18
Thalassiosira cf. *T. decipiens* (Grunow) JØRGENSEN, 1905, p. 96, pl. 6, fig. 3; BARRON, 1975, p. 157, pl. 13, fig. 11, 14

THALASSIOSIRA EXCENTRICA (Ehrenberg) Cleve
Pl. 10, fig. 9

Coscinodiscus excentricus EHRENBERG, 1839, p. 146
Thalassiosira excentrica (Ehrenberg) CLEVE, 1903, p. 216; Schrader, 1974b, p. 916, pl. 11, fig. 7-8; pl. 14, fig. 6-7, 9-10

THALASSIOSIRA GRAVIDA Cleve forma FOSSILIS Jousé
Pl. 10, fig. 10

Thalassiosira gravida Cleve forma *fossilis* JOUSÉ, 1961, p. 63, pl. 1, fig. 9; KOIZUMI, 1975a, p. 803, pl. 5, fig. 7, 8, 9, 10

THALASSIOSIRA HYALINA (Grunow) Gran
Pl. 10, fig. 11

Coscinodiscus hyalinus Grunow *in* CLEVE and GRUNOW, 1880, p. 113, pl. 7, fig. 128
Thalassiosira hyalina (Grunow) GRAN, 1887, p. 4, pl. 1, fig. 17, 18; KOIZUMI, 1973, p. 834, pl. 8, fig. 1, 2

THALASSIOSIRA HYALINOPSIS Barron
Pl. 10, fig. 12

Thalassiosira hyalinopsis BARRON, 1975, p. 157, pl. 13, fig. 12, 15 (with description)

THALASSIOSIRA MIOCENICA Schrader
Pl. 10, fig. 13

Thalassiosira miocenica SCHRADER, 1974b, p. 916, pl. 22, fig. 4 (with description and discussion)

THALASSIOSIRA NATIVA Sheshukova-Poretzkaya
Pl. 10, fig. 14

Thalassiosira nativa SHESHUKOVA-PORETZKAYA, 1959, p. 41, pl. 1, fig. 8; BARRON, 1975, p. 158, pl. 14, fig. 4

THALASSIOSIRA NIDULUS (Tempère and Brun) Jousé
Pl. 10, fig. 15

Stephanopyxis nidulus Tempère and Brun *in* BRUN and TEMPÈRE, 1889, p. 57, pl. 8, fig. 10
Thalassiosira nidulus (Tempère and Brun) JOUSÉ, 1961, p. 63, pl. 3, fig. 4-5; SCHRADER, 1973, p. 712, pl. 11, fig. 1-7

THALASSIOSIRA OESTRUPII (Ostenfeld) Proshkina-Lavrenko
Pl. 10, fig. 16, 17, 18

Coscinosira oestrupii OSTENFELD, 1900, p. 52
Thalassiosira oestrupii (Ostenfeld) PROSHKINA-LAVRENKO, 1960, p. 8, pl. 1, fig. 5, 7, 11; BARRON, 1975, p. 158, pl. 14, fig. 5, 6

THALASSIOSIRA cf. T. PACIFICA Gran and Angst
Pl. 10, fig. 19

Thalassiosira pacifica GRAN and ANGST, 1931, p. 437-438, fig. 12; p. 712, pl. 25, fig. 18, 20, 21; pl. 14, fig. 13, 14

THALASSIOSIRA PRAECONVEXA Burckle
Pl. 10, fig. 20

PLATE 11

1. *Thalassiosira* sp. 3. 60, -28 microns, x1350.
2. *Thalassiosira* sp. 6. 60, +28 microns, x600.
3. *Thalassiothrix longissima* Cleve and Grunow. 73, -28 microns, x1000.
4. *Triceratium arcticum* Brightwell. 49, +28 microns, x400.
5. *Triceratium condecorum* Ehrenberg. 51, +28 microns, x500.
6. *Triceratium elegans* (Greville) Grunow. 67, +28 microns, x400.
7. *Triceratium thumii* Schmidt. 44, +28 microns, x400.
8. *Triceratium validum* Grunow. 42, +28 microns, x400.
9. *Xanthiopyxis oblonga* Ehrenberg. 54, -28 microns, x1250.
10. *Xanthiopyxis ovalis* Lohman (spore). 73, -28 microns, x1200.
11. *Xanthiopyxis* sp. (spore). 64, +28 microns, x700.
12. *Xanthiopyxis* sp. (spore). 64, +28 microns, x400.

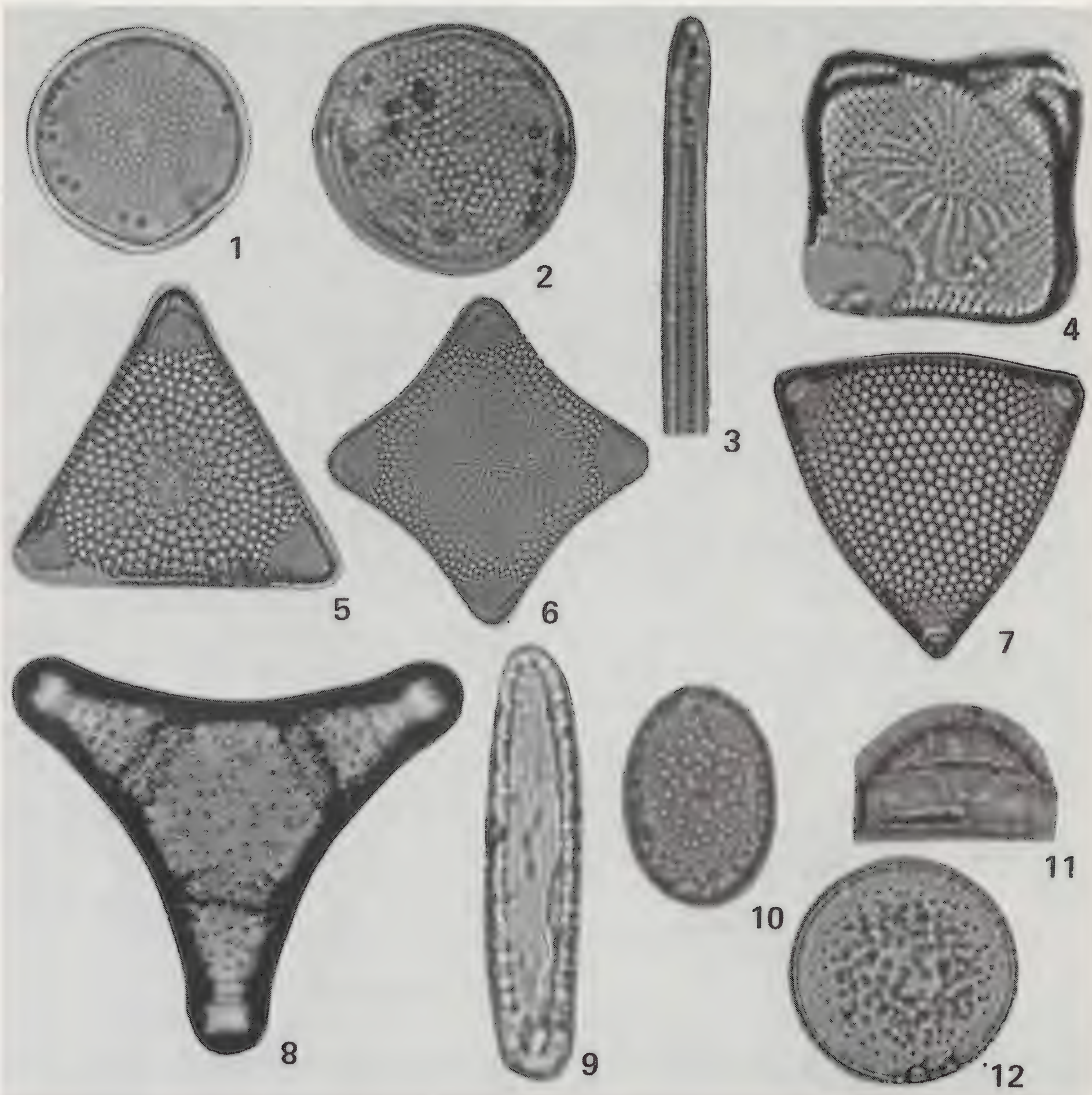


PLATE 11

Thalassiosira praeconvexa BURCKLE, 1972, p. 242, pl. 2, fig. 7-9 (with description); BARRON, 1975, p. 158, pl. 14, fig. 9

THALASSIOSIRA PUNCTATA Jousé
Pl. 10, fig. 21

Thalassiosira punctata JOUSÉ, 1959, p. 55, pl. 4, fig. 5, 17; SCHRADER, 1973, p. 712, pl. 17, fig. 20

THALASSIOSIRA ZABELINAE Jousé
Pl. 10, fig. 22-23

Thalassiosira zabelinae JOUSÉ, 1959, p. 41, pl. 2, fig. 1a, b; KOIZUMI, 1973, p. 834, pl. 8, fig. 10-12

THALASSIOSIRA sp. 3
Pl. 11, fig.1

Thalassiosira sp. 3 SCHRADER, 1973, p. 712, pl. 14, fig. 19, 20

THALASSIOSIRA sp. 6
Pl. 11, fig. 2

Thalassiosira sp. 6 SCHRADER, 1973, p. 712, pl. 17, fig. 21-23

Genus THALASSIOTHRIX Cleve and Grunow, 1880

THALASSIOTHRIX LONGISSIMA Cleve and Grunow
Pl. 11, fig. 3

Thalassiothrix longissima Cleve and Grunow *in* CLEVE and MÖLLER, 1878, no. 118; BARRON, 1975, pl. 14, fig. 10, 11

Modern distribution: North boreal (Jousé *et al.*, 1969).

Genus TRICERATIUM Ehrenberg, 1840

TRICERATIUM ARCTICUM Brightwell
Pl. 11, fig. 4

Triceratium arcticum BRIGHTWELL, 1853, p. 250, pl. 4, fig. 11; BARRON, 1975, pl. 14, fig. 13

TRICERATIUM CONDECORUM Ehrenberg
Pl. 11, fig. 5

Triceratium condecorum EHRENBERG, 1844, p. 272; BARRON, 1975, p. 159, pl. 14, fig. 15; pl. 15, fig. 4

TRICERATIUM ELEGANS (Greville) Grunow
Pl. 11, fig. 6

Amphitetras elegans GREVILLE, 1866, p. 9, pl. 2, fig. 717

Triceratium elegans (Greville) Grunow *in* VAN HEURCK, 1883, pl. 109, fig. 1; BARRON, 1975, p. 160, pl. 15, fig. 1

TRICERATIUM THUMII Schmidt
Pl. 11, fig. 7

Triceratium thumii SCHMIDT, 1886, pl. 93, fig. 2; WORNARDT, 1967, p. 67, fig. 129

TRICERATIUM VALIDUM Grunow
Pl. 11, fig. 8

Triceratium validum Grunow *in* SCHMIDT, 1886, pl. 94, fig. 5; HANNA, 1970, p. 195, p. 229, fig. 85

Genus XANTHIOPYXIS Ehrenberg, 1844

XANTHIOPYXIS OBLONGA Ehrenberg
(resting spore)
Pl. 11, fig. 9

Xanthiopyxis oblonga EHRENBERG, 1844, p. 273; BARRON, 1975, p. 161, pl. 15, fig. 12

XANTHIOPYXIS OVALIS Lohman
(resting spore)
Pl. 11, fig. 10

Xanthiopyxis ovalis LOHMAN, 1938, p. 91, pl. 20, fig. 6; pl. 22, fig. 12; BARRON, 1975, p. 161, pl. 15, fig. 13

XANTHIOPYXIS sp. (resting spore)
Pl. 11, fig. 11

Xanthiopyxis sp. D. WORNARDT, 1967, p. 73, 76, 77, fig. 155, 155a

XANTHIOPYXIS sp. (resting spore)
Pl. 11, fig. 12

Xanthiopyxis sp. BARRON, 1975, p. 161, pl. 15, fig. 15

CHECK CHARTS, NOTE

Check charts I-III were designed to display a concise overview of the diatom inventories for the beds exposed in the Sweeny Road section. Check charts IV-VI tabulate the occurrence of some of the taxa that contemporary diatomists have found to be the most biostratigraphically useful for deep sea cores and outcrops in the North Pacific Ocean regions.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number \ Taxa	ACTINOCYCLUS CHOLNOKYI	ACTINOCYCLUS CUBITUS	ACTINOCYCLUS CURVATULUS	ACTINOCYCLUS EHRENBERGII	ACTINOCYCLUS EHRENBERGII VAR. ASTERISCUS	ACTINOCYCLUS EHRENBERGII VAR. TENELLA	ACTINOCYCLUS ELLIPTICUS	ACTINOCYCLUS ELLIPTICUS VAR. MORONENSIS	ACTINOCYCLUS INGENS	ACTINOCYCLUS OCHOTENSIS	ACTINOCYCLUS OCULATUS	ACTINOCYCLUS TSUGARUENIS	ACTINOPTYCHUS BISMARCKII	ACTINOPTYCHUS CLEVEI	ACTINOPTYCHUS SPLENDENS VAR. HALIONYX	ACTINOPTYCHUS SPLENDENS VAR. INCISA	ACTINOPTYCHUS STELLA VAR. CLEVEI	ACTINOPTYCHUS UNDULATUS	ACTINOPTYCHUS VULGARIS VAR. MONICAE	ARACHNOIDISCUS DECORUS	ARACHNOIDISCUS EHRENBERGII	ARACHNOIDISCUS ORNATUS VAR. MONTEREYANUS	ASTEROMPHALUS DARWINII	AULACODISCUS CONCENTRICUS	AULACODISCUS KITTONI	AULACODISCUS MARGARITACEUS	AULACODISCUS SIMPLEX	AULISCUS CAELATUS	AULISCUS CAELATUS VAR. CONSTRICTA	AULISCUS PUNCTATUS
	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018	019	020	021	022	023	024	025	026	027	028	029	030
73	X	·	●	X	·	·	·	·	·	X	X	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·
72	X	·	●	/	·	·	·	·	·	X	X	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·
71	O	·	●	/	·	·	·	·	·	X	/	·	/	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·
70	·	·	O	·	·	·	·	·	·	·	/	·	/	/	/	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·
69	X	·	/	·	·	·	·	·	·	/	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·
68	·	·	·	X	·	/	·	·	·	/	X	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·
67	·	·	/	/	·	/	·	·	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
66	/	X	X	/	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
65	·	·	·	/	·	/	/	·	·	·	/	·	/	·	·	·	·	/	/	·	·	·	·	·	·	·	·	·	·	·
64	·	·	·	·	·	·	/	·	/	·	·	·	·	·	·	·	·	/	·	·	·	·	·	/	·	·	·	·	·	·
63	·	·	·	X	·	·	·	·	·	·	X	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
62	X	·	·	/	·	·	·	·	X	·	/	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·
61	·	·	·	/	·	·	·	·	·	/	·	·	X	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·
60	/	·	·	X	·	/	·	·	·	X	X	·	·	·	·	·	·	O	·	·	·	·	·	·	·	·	·	·	·	·
59	·	/	·	/	·	/	/	·	/	·	·	·	·	·	·	·	·	O	·	·	·	·	·	·	/	·	·	·	·	·
58	·	/	·	/	·	·	·	·	·	·	·	·	/	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·
57	·	·	/	/	·	·	·	·	·	X	·	·	·	·	·	·	X	X	·	·	·	·	·	·	·	·	·	·	·	·
56	·	·	/	/	·	·	·	·	·	X	·	·	·	·	·	·	X	X	·	·	·	·	·	·	·	·	·	·	·	·
55	·	/	/	X	/	·	·	·	/	·	·	·	·	·	·	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·
54	X	X	·	/	·	/	·	·	/	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	X	·	·	·	·	·
53	·	·	·	/	·	X	/	·	·	X	·	·	·	·	·	·	·	/	·	·	·	·	·	·	/	·	·	·	·	·
52	X	·	·	·	·	/	·	·	X	·	·	·	X	·	·	/	·	/	·	·	·	·	·	·	·	·	·	·	·	·
51	·	·	·	·	·	·	·	·	X	/	·	·	·	·	·	·	/	/	·	·	·	·	/	·	·	·	·	·	·	·
50	·	·	·	X	·	·	X	·	O	·	·	·	·	·	·	X	·	O	·	·	·	/	·	·	·	/	·	/	·	·
49	/	·	·	/	·	·	·	·	X	/	·	·	/	/	·	·	/	O	·	·	·	·	·	·	·	/	·	·	·	·
48	·	/	·	·	·	/	·	·	/	·	·	·	/	·	·	·	·	/	·	·	·	·	·	/	·	·	·	/	·	·
47	·	·	/	X	·	·	·	·	/	/	·	·	·	·	/	·	·	X	·	·	·	·	·	·	/	·	·	·	·	·
46	X	·	·	/	O	·	·	·	·	·	O	·	/	/	·	·	X	·	·	·	·	·	·	·	/	·	·	·	·	/
45	·	/	·	·	●	·	·	·	O	·	X	·	·	·	·	/	/	·	·	·	/	·	·	·	·	·	/	·	·	·
44	·	·	·	/	O	X	/	·	X	/	/	·	·	/	·	·	X	/	·	·	·	·	/	·	·	·	·	·	·	·
43	/	·	X	·	●	·	·	·	X	·	X	·	·	·	/	·	·	·	·	·	·	·	·	/	·	·	·	X	·	·
42	X	X	·	X	X	·	·	/	·	·	·	·	X	/	/	·	·	·	O	·	/	/	·	/	·	·	·	·	·	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	·	·	·	X	·	X	·	/	X	·	/	/	·	·	·	·	/	X	/	X	/	/	·	·	·	·	/	·	/	/

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
O = Common. 1 Specimen Within 2 Field of View.
X = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number \ Taxa	BACTERIASTRUM SP.	BIDDULPHIA AURITA	BIDDULPHIA AURITA VAR. OBTUSA	BIDDULPHIA RHOMBUS	BIDDULPHIA SUBORBICULARIS	BIDDULPHIA TRIDENS	CESTODISCUS PULCHELLUS VAR. MACULATUS	CHAETOCEROS CINCTUS	CHAETOCEROS DIADEMA	CHAETOCEROS DICLADIA	CHAETOCEROS SPECIES [SPORE]	CLADOGRAMMA CALIFORNICUM	CLADOGRAMMA DUBUIM	COCCONEIS COSTATA	COCCONEIS DECIPIENS	COCCONEIS DIRUPTA VAR. TRIUMPHIS	COSCINODISCUS ANTIQUUS	COSCINODISCUS ASTEROMPHALUS	COSCINODISCUS BIRADIATUS	COSCINODISCUS EXCENTRICUS VAR. LEASAREOLATUS	COSCINODISCUS HIROSAKIENSIS	COSCINODISCUS KURZII	COSCINODISCUS MARGINATUS	COSCINODISCUS MONICAE	COSCINODISCUS NITIDUS	COSCINODISCUS NODULIFER	COSCINODISCUS OBSCURUS	COSCINODISCUS OCULUSIRIDIS VAR. BOREALIS	COSCINODISCUS OCULUSIRIDIS VAR. OCULUSIRIDIS	COSCINODISCUS PILOSUS
	031	032	033	034	035	036	037	038	039	040	041	042	043	044	045	046	047	048	049	050	051	052	053	054	055	056	057	058	059	060
73	X	·	·	·	·	·	·	/	X	0	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	X	·
72	X	X	·	·	·	·	·	/	0	X	·	·	·	·	·	·	/	·	·	/	·	·	X	·	·	·	·	·	0	·
71	·	X	·	·	·	/	·	·	/	X	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	0	·
70	·	·	·	·	·	·	·	·	·	/	·	·	·	/	·	·	·	·	·	·	·	·	X	·	·	·	·	/	X	·
69	·	/	·	·	·	·	·	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	X	0	·
68	/	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·
67	/	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·
66	/	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	0	·
65	·	·	·	·	·	·	·	·	/	/	·	·	·	/	·	·	·	·	·	/	·	·	·	·	·	·	·	X	●	·
64	/	·	·	·	·	X	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	/	0	·
63	·	·	·	·	·	·	·	·	/	X	·	·	·	·	·	·	X	·	·	·	·	·	X	·	·	·	·	·	X	·
62	·	·	·	·	·	·	·	·	/	X	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·
61	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	X	·
60	·	·	/	·	·	·	·	X	·	X	·	·	·	·	·	·	·	·	·	·	·	·	0	·	·	·	·	·	0	·
59	X	·	·	·	·	·	·	·	·	/	·	·	·	/	·	·	·	·	·	/	·	·	/	·	·	·	·	/	0	·
58	0	X	·	·	·	·	·	/	·	X	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	X	X	·
57	X	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·
56	X	·	·	·	·	·	·	·	/	X	·	·	·	·	·	·	·	·	·	X	·	·	X	·	·	·	·	X	0	·
55	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	/	0	·
54	·	/	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	X	·	·	·	·	X	·	·	·	·	X	0	·
53	·	X	·	·	·	·	·	·	/	·	·	·	·	/	·	·	·	·	·	·	·	·	X	·	·	·	/	·	X	·
52	X	·	·	·	·	·	·	·	0	·	·	·	·	·	·	·	·	·	·	·	/	·	X	·	·	·	·	·	X	·
51	/	·	·	·	·	X	·	·	X	X	·	·	·	·	·	·	·	0	·	·	·	·	0	·	·	/	X	·	0	·
50	/	·	·	·	·	/	·	X	·	X	·	·	/	·	·	·	·	X	·	·	·	·	●	·	·	/	/	X	●	·
49	·	/	·	·	·	·	·	/	·	·	·	/	·	·	·	X	·	X	·	·	·	·	●	·	·	/	·	X	●	·
48	·	·	·	·	/	·	·	X	/	·	/	·	/	·	·	·	·	X	·	·	·	·	●	/	·	·	·	·	X	·
47	·	·	·	·	/	·	·	/	·	·	·	·	·	·	·	/	·	0	·	·	·	·	0	X	·	·	·	/	0	·
46	·	·	·	·	·	·	·	·	·	·	/	X	·	·	·	·	·	/	·	·	/	·	X	·	/	·	X	/	0	·
45	·	/	·	/	·	·	·	/	·	/	X	·	·	X	·	·	·	·	·	·	·	·	0	/	/	·	/	·	X	·
44	·	·	·	·	·	·	·	X	·	·	·	·	/	·	·	·	·	/	·	·	·	·	0	/	·	/	·	·	X	·
43	·	/	·	·	·	·	·	/	X	/	·	/	·	·	·	·	·	X	·	·	·	/	X	·	/	·	/	X	0	·
42	·	·	/	·	·	/	·	X	/	/	/	/	·	·	·	·	·	X	·	·	·	·	X	X	·	/	·	X	0	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	·	·	·	/	·	/	/	·	·	·	·	/	·	·	/	/	·	X	/	·	X	/	●	X	/	/	/	/	X	●

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number \ Taxa	COSCINODISCUS PLICATUS 061	COSCINODISCUS RADIATUS 062	COSCINODISCUS ROBUSTUS VAR. INCRETUS 063	COSCINODISCUS STELLARIS VAR. SYMBOLOPHORA 064	COSCINODISCUS SUBTILIS 065	COSCINODISCUS TABULARIS VAR. EGREGIUS 066	COSCINODISCUS VESTUSTISSIMUS 067	DENTICULOPSIS DIMORPHA 068	DENTICULOPSIS HUSTEDII 069	DENTICULOPSIS HYALINA 070	DENTICULOPSIS KAMTSCHATICA 071	DENTICULOPSIS SEMINAE VAR. FOSSILIS 072	DIMEROGRAMMA SP.? 073	DIPLONEIS CRABRO 074	DOSSETIA LACERA 075	ENDICTYA OCEANICA 076	ENDICTYA ROBUSTUS 077	ENTOPYLA AUSTRALIS VAR. GIGANTEA 078	GLYPHODESMUS WILLIAMSONII 079	GLYPHODISCUS STELLATUS 080	GRAMMATOPHORA ANGULOSA 081	GRAMMATOPHORA MERLETTA 082	HEMIAULUS POLYMORPHUS 083	HEMIDISCUS CUNEIFORMIS 084	HEMIDISCUS SIMPLICISSIMUS 085	HERCOTHECA MAMILLARIS 086	LIHODESMIUM ASKETOGONIUM 087	LIHODESMIUM CORNIGERUM 088	LIHODESMIUM MINUSCULUM 089	MELOSIRA CLAVIGERA 090
73	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	X	·
72	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	X	/	·
71	·	X	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	/	·
70	·	/	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·
69	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	0	X	·
68	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	0	X	·
67	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	X	·
66	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	/	·	·	●	/	·
65	·	X	·	·	X	·	·	·	·	·	·	·	·	·	/	X	·	·	·	·	·	·	·	·	·	·	●	/	·
64	/	·	·	·	·	·	·	·	·	/	·	·	·	·	·	0	·	·	·	·	·	·	·	·	·	·	●	/	·
63	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	X	·
62	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	X	·	·	·	X	·
61	·	/	·	·	/	·	·	·	·	·	/	/	/	·	·	/	·	·	·	·	·	·	·	/	·	·	0	X	·
60	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	0	X	·
59	·	X	·	·	X	·	·	·	/	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	0	X	·
58	·	X	·	·	·	·	·	·	·	·	/	/	X	·	·	·	·	·	·	·	·	·	·	·	·	/	0	X	·
57	·	X	·	X	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	/	·	·	·	·	0	X	/
56	·	/	·	/	·	·	·	·	·	·	X	·	0	·	·	·	·	·	·	·	·	X	·	·	·	/	X	/	0	/
55	·	/	·	·	·	·	·	·	0	·	·	·	X	·	·	X	·	·	·	·	·	·	·	·	·	·	/	/	●	/
54	·	X	/	·	·	·	·	·	X	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	X	/	0	·
53	·	·	·	·	·	·	·	·	·	/	X	·	·	·	/	·	·	·	·	·	·	/	·	·	·	/	/	·	/	·
52	·	/	·	·	/	·	·	·	·	·	·	·	·	·	X	·	·	·	/	·	·	·	·	X	·	·	·	·	0	X
51	·	X	·	/	·	·	·	·	·	·	·	·	/	·	/	/	·	/	X	/	·	·	/	/	·	·	X	·	X	·
50	·	0	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	/	·	·	·	·	X	·	0	/
49	·	0	·	·	·	·	·	·	X	·	/	·	·	·	/	·	·	·	/	·	·	·	·	/	·	·	0	·	0	·
48	·	X	·	/	·	·	·	·	X	·	·	·	·	·	X	·	·	/	·	/	X	·	X	·	·	·	X	·	X	·
47	·	0	·	·	·	·	/	·	·	·	·	·	·	·	X	·	·	·	/	·	/	·	·	X	·	·	X	·	·	·
46	·	X	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	/	·	/	·	X	X
45	·	·	·	·	·	·	·	·	/	·	/	·	·	·	·	/	·	·	/	·	·	·	·	·	·	·	·	·	X	/
44	·	·	·	·	·	·	·	·	X	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	/	·	/	/
43	·	0	·	·	·	·	·	Δ	/	·	·	·	·	·	·	/	/	·	/	·	/	·	·	0	·	·	·	·	X	X
42	·	X	·	/	·	/	·	·	X	/	/	·	·	·	/	/	X	/	·	/	·	·	X	·	·	·	X	·	X	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	·	X	/	·	·	/	/	·	X	/	·	·	·	/	X	·	/	X	X	·	·	/	/	/	·	·	·	·	X	0

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number \ Taxa	MELOSIRA SULCATA VAR. BISERIATA	MELOSIRA SULCATA VAR. CORONATA	MELOSIRA SULCATA VAR. SIBERICA	MUELLERIELLA LIMBATA	NAVICULA LYRA VAR. EHRENBERGII	NAVICULA OPTIMA	NITZSCHIA CALIFORNICA	NITZSCHIA FOSSILIS	NITZSCHIA JOUSEAE	NITZSCHIA MIOCENICA	NITZSCHIA REINHOLDII	NITZSCHIA ROLANDII	OPEPHORA SCHWARTZII	PERIPTERA TETRACLADIA	POSOSIRA GLACIALIS	PSEUDOEUNOTIA DOLIOLUS	PSEUDOPYXILLA AMERICANA	PSEUDOPYXILLA DUBIA	RHABDONEMA JAOPNICUM	RHAPHONEIS AMPHICEROS VAR. ELONGATA	RHAPHONEIS AMPHICEROS VAR. GEMMIFERA	RHAPHONEIS FATULA	RHAPHONEIS MIOCENICA	RHAPHONEIS SACHALINENSIS	RHIZOSOLENIA BARBOI	RHIZOSOLENIA CF. R. ALATA	RHIZOSOLENIA HEBETATA	RHIZOSOLENIA PRAEBERGONII	RHIZOSOLENIA STYLIFORMIS	ROSSIELLA PRAEPALEACEUS
	091	092	093	094	095	096	097	098	099	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
73	0	/	·	/	/	/	X	·	·	·	·	·	·	X	·	/	·	·	·	X	0	/	·	·	X	X	X	·	/	·
72	X	·	·	X	·	·	·	·	·	·	·	·	·	/	·	/	·	·	·	/	X	X	·	·	/	·	X	·	·	·
71	X	·	·	·	·	X	·	/	·	·	·	·	·	·	·	·	·	·	·	/	X	·	·	·	·	/	X	·	·	·
70	X	·	·	·	·	·	/	·	·	·	·	·	·	/	·	·	·	·	X	0	·	·	·	·	X	·	X	·	·	·
69	/	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·
68	·	X	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	X	·	·	·	/	·	·
67	·	X	·	X	X	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·
66	·	·	·	·	·	X	·	·	·	·	·	/	·	/	·	·	·	·	·	·	X	·	·	·	/	/	X	·	·	·
65	X	·	·	·	·	X	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	0	/	·	/	·	·	·
64	·	·	·	/	/	·	·	·	·	·	·	·	·	/	·	·	·	·	·	/	·	·	·	X	X	·	/	/	·	X
63	·	/	·	·	·	/	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	X	/	·	·	·	·	·
62	·	·	·	/	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	/	·	·	●	·	·	X	·	·	·
61	·	/	·	·	/	·	·	·	/	·	X	·	·	/	·	·	·	·	·	·	X	·	·	●	/	·	/	·	X	·
60	X	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	0	X	·	/	·	·	·
59	X	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	X	·	·	/	·	·	·
58	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	0	·	·	X	/	·	X	·	·	·
57	·	·	·	X	·	·	·	·	/	·	X	·	·	·	·	·	·	·	·	·	0	·	·	X	·	·	X	·	·	·
56	/	·	·	·	·	/	/	·	·	·	·	·	·	X	·	·	·	·	·	·	X	/	/	0	X	·	X	·	·	·
55	·	/	·	·	·	·	·	·	·	·	X	X	·	/	·	·	·	·	·	·	X	X	·	0	·	·	X	·	·	·
54	/	·	·	/	·	X	·	·	·	·	·	/	·	·	/	·	·	·	/	·	X	·	·	X	X	·	X	·	·	·
53	·	/	·	·	·	/	/	·	/	·	/	·	·	/	X	·	·	·	·	·	X	·	/	/	·	·	X	·	X	·
52	·	·	·	·	·	X	·	·	·	·	·	X	·	·	·	·	/	·	·	·	0	·	·	0	/	·	/	·	·	·
51	X	·	·	·	·	X	·	/	·	·	·	·	·	·	·	·	·	·	/	·	0	·	·	0	·	·	/	·	X	·
50	/	·	·	·	/	X	·	·	·	/	·	·	·	·	X	X	·	/	X	·	/	·	·	0	·	·	X	·	/	·
49	·	/	/	·	X	/	·	·	·	·	/	·	·	X	·	·	/	X	X	·	X	/	·	0	·	/	X	·	/	·
48	·	·	·	/	/	·	·	/	·	·	/	·	·	X	/	·	/	/	·	·	X	·	·	X	/	·	X	·	·	·
47	/	X	·	·	·	X	·	·	·	·	·	·	·	X	·	·	·	/	/	·	X	·	·	●	·	·	X	·	X	·
46	·	·	·	·	·	X	/	·	·	/	X	/	·	X	·	·	/	/	·	·	X	/	·	●	·	·	/	·	·	·
45	·	/	·	·	·	/	·	·	·	·	X	/	·	·	·	·	X	X	/	·	/	·	·	●	X	/	X	·	·	·
44	·	·	·	·	/	X	/	/	·	·	0	X	/	/	·	·	/	/	·	·	X	·	·	0	X	·	X	·	·	·
43	/	·	·	/	·	·	·	·	·	·	0	·	/	/	·	·	/	/	·	/	X	·	·	0	/	·	X	·	·	·
42	·	X	·	·	/	X	·	·	·	/	0	X	·	·	·	·	/	X	/	X	X	·	·	0	·	/	/	·	/	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	/	/	X	·	/	/	·	·	·	·	·	·	·	/	·	·	·	X	/	0	/	·	·	X	·	·	X	·	/	/

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number \ Taxa	ROUXIA CALIFORNICA	ROUXIA YABEI	STEPHANODISCUS SP.	STEPHANOGONIA HANZAWAE	STEPHANOGONIA POLYACANTHA	STEPHANOPYXIS APPENDICULATA	STEPHANOPYXIS HORRIDUS	STEPHANOPYXIS SPINOSSIMA	STEPHANOPYXIS TURRIS	STRICTODISCUS BURYANUS	STRICTODISCUS CALIFORICUS	SYNEDRA JOUSEANA	THALASSIONEMA ANTIQUA	THALASSIONEMA HIROSAKIENSIS	THALASSIONEMA NITZSCHIODES	THALASSIOSIRA ANTIQUA	THALASSIOSIRA CF.T.DECIPIENS	THALASSIOSIRA CF.T.PACIFICA	THALASSIOSIRA CONVEXA	THALASSIOSIRA CONVEXA VAR. ASPINOSA	THALASSIOSIRA EXCENTRICA	THALASSIOSIRA GRAVIDA CF.T.FORMA FOSSILIS	THALASSIOSIRA HYALINA	THALASSIOSIRA HYLINOPSIS	THALASSIOSIRA MIOCENICA	THALASSIOSIRA NATIVA	THALASSIOSIRA NIDULUS	THALASSIOSIRA OESTRUPII	THALASSIOSIRA PRAECONVEXA	THALASSIOSIRA PUNCTATA
	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
73	·	·	·	·	·	X	X	·	X	·	·	·	X	·	0	X	·	·	·	·	·	X	·	·	·	·	·	X	·	·
72	·	·	·	·	·	X	X	·	/	·	·	·	X	·	0	X	·	·	·	·	·	X	·	·	·	·	·	/	·	·
71	·	·	·	·	·	X	·	·	·	·	·	·	X	·	●	X	·	·	·	·	·	0	·	·	·	·	·	X	·	·
70	·	·	·	·	·	·	/	·	X	·	·	·	0	·	●	0	·	·	·	·	·	0	·	·	·	·	·	X	·	·
69	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·
68	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	/	·	·	·	·	·	·	·	·	·	·	·	/	·	·
67	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·
66	·	·	·	·	·	·	·	·	/	·	·	·	/	·	0	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·
65	·	·	·	·	·	·	/	·	/	·	·	·	X	·	0	X	·	·	·	·	·	/	·	·	·	·	·	/	·	·
64	·	·	·	·	·	X	·	·	/	·	·	·	●	·	0	●	·	·	·	·	·	·	·	·	·	·	X	·	·	·
63	·	·	·	·	·	·	·	·	X	·	·	·	·	·	X	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·
62	·	·	·	·	·	·	/	·	X	·	·	·	/	·	X	·	/	·	/	·	·	/	·	/	·	·	/	X	·	·
61	·	·	·	·	·	/	·	·	X	·	·	·	·	·	X	●	·	/	·	·	·	/	·	/	·	·	·	X	·	·
60	·	·	·	·	·	/	·	·	/	·	·	·	/	·	X	●	·	·	·	·	·	·	/	/	·	·	·	X	·	·
59	·	·	·	·	·	X	·	·	·	·	·	·	·	·	X	●	·	·	/	·	·	·	·	X	·	·	·	0	·	·
58	·	·	·	·	·	/	·	·	/	·	·	·	X	·	X	●	·	·	X	·	·	/	·	X	·	·	·	0	·	·
57	·	·	·	·	·	·	·	·	/	·	·	·	/	·	X	●	·	·	X	/	·	·	·	X	·	/	/	·	·	·
56	·	·	·	·	·	/	·	·	·	·	·	·	·	·	X	●	·	·	/	·	·	·	·	/	·	X	X	·	·	·
55	·	·	·	·	·	/	·	·	·	·	/	·	/	·	X	/	X	·	·	·	·	/	/	·	·	/	·	/	·	·
54	·	·	·	·	·	·	/	·	X	·	·	·	0	·	0	0	·	·	/	·	·	/	·	X	·	/	·	/	·	·
53	·	·	·	·	·	·	·	·	X	·	X	·	X	·	0	X	·	·	·	·	/	·	·	X	·	·	·	X	·	·
52	·	·	·	·	·	X	·	·	/	·	·	·	●	·	●	●	·	·	·	·	·	·	X	/	·	·	·	·	·	·
51	·	·	·	·	·	X	·	·	X	·	·	·	●	·	●	●	/	·	/	/	X	·	/	/	·	·	/	·	·	·
50	·	·	·	·	·	·	·	·	X	/	·	·	/	·	●	/	·	/	·	·	/	·	·	/	·	·	·	·	·	·
49	/	·	·	·	·	·	·	·	X	/	·	/	X	·	●	X	·	·	·	·	/	·	·	·	/	·	/	·	·	·
48	·	·	/	·	/	·	·	·	/	·	·	·	X	·	●	X	/	/	·	·	·	·	·	·	·	·	·	·	·	·
47	X	·	·	·	·	X	·	·	/	·	·	X	·	·	0	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·
46	·	·	·	·	·	·	·	·	0	·	·	·	0	·	X	0	·	·	·	/	X	·	·	·	·	X	X	·	·	·
45	·	·	·	/	·	/	·	·	0	/	·	/	0	·	X	0	·	·	·	X	·	·	·	·	·	·	/	·	·	/
44	/	·	·	X	·	/	·	·	0	X	·	·	0	·	0	0	·	·	/	X	/	·	·	·	·	·	·	·	·	·
43	·	·	·	·	·	/	·	·	0	X	·	·	/	·	0	/	·	·	·	·	·	·	·	·	/	/	·	·	/	·
42	·	·	·	·	/	·	·	·	0	X	/	X	●	/	/	●	/	·	·	/	/	/	/	/	/	·	·	·	·	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	·	/	·	·	·	·	·	/	·	●	X	/	/	/	/	/	·	·	·	·	/	·	·	·	/	X	·	/	·	·

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart I
Sweeny Road Diatoms
Alphabetized

Sample Number \ Taxa	THALASSIOSIRA SP.3 (151)	THALASSIOSIRA SP.6 (152)	THALASSIOSIRA ZABELINAE (153)	THALASSIOTHRIX LONGISSIMA (154)	TRICERATIUM ARCTICUM (155)	TRICERATIUM CONDECORUM (156)	TRICERATIUM ELEGANS (157)	TRICERATIUM THUMII (158)	TRICERATIUM VALIDUM (159)	XANTHIOPYXIS N. SP. D (160)	XANTHIOPYXIS OBLONGA (161)	XANTHIOPYXIS OVALIS (162)	XANTHIOPYXIS SP. (163)	TOTAL SPECIES PRESENT (164)
73	·	·	/	/	·	·	·	·	·	·	·	·	·	40
72	·	·	·	X	·	·	·	·	·	·	·	·	·	37
71	·	·	·	X	·	·	·	·	·	·	·	·	·	31
70	·	·	/	X	·	·	·	·	·	·	·	·	·	30
69	·	·	·	·	·	·	·	·	·	·	·	·	·	18
68	·	·	·	·	·	·	·	·	·	·	·	/	·	19
67	·	·	·	·	·	·	/	·	·	·	X	·	·	20
66	·	·	·	/	·	·	·	·	·	·	/	·	·	27
65	·	·	·	·	·	·	·	·	·	·	·	·	·	32
64	·	·	/	·	·	·	·	·	·	·	·	·	·	31
63	·	·	·	/	·	·	·	·	·	·	·	·	·	20
62	·	·	·	X	·	·	·	·	·	·	·	·	·	28
61	·	·	·	·	·	·	·	·	·	·	·	·	·	34
60	·	·	·	·	·	·	/	·	·	·	·	·	·	28
59	·	·	·	/	·	·	·	·	·	·	·	·	·	32
58	·	·	·	X	·	·	·	·	·	·	/	·	·	34
57	/	·	·	·	·	·	·	·	·	·	·	/	/	33
56	·	·	·	X	·	·	·	·	·	·	·	/	/	42
55	·	·	·	/	·	·	·	·	/	·	·	·	·	40
54	·	·	·	X	·	·	·	·	·	·	·	·	/	42
53	/	·	·	X	·	·	·	·	·	·	·	·	·	41
52	·	·	·	O	·	·	·	·	·	·	·	·	·	33
51	·	·	·	O	·	·	·	·	/	·	·	·	·	48
50	·	·	·	●	·	·	·	·	·	·	/	/	·	48
49	·	·	·	●	·	/	·	·	·	·	·	X	/	55
48	·	·	·	O	·	·	·	·	·	·	·	·	X	48
47	·	·	·	O	·	·	·	·	·	X	/	/	X	43
46	·	·	·	●	·	/	·	·	·	X	·	X	X	50
45	·	/	·	●	/	·	·	·	/	/	/	·	/	55
44	·	·	·	O	·	·	·	·	·	·	/	·	X	51
43	·	·	·	/	·	·	·	·	·	/	·	·	/	54
42	·	/	·	X	/	·	·	/	·	X	/	/	X	78
41	·	·	·	·	·	·	·	·	·	·	·	·	·	0
40	·	·	·	·	·	·	·	·	·	·	·	·	·	0
39	·	·	·	/	·	/	·	/	·	●	X		/	82

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Sample Number \ Taxa	ACTINOCYCLUS CHOLNOKYI	ACTINOCYCLUS CURVATULUS	ACTINOCYCLUS EHRENBERGII	ACTINOCYCLUS OCHOTENSIS	ACTINOCYCLUS OCULATUS	ACTINOPTYCHUS UNDULATUS	BACTERIASTRUM SP.	CHAETOCEROS CINCTUS	CHAETOCEROS DIADEMA	CHAETOCEROS DICLADIA	COSCINODISCUS MARGINATUS	COSCINODISCUS OCULUSIRIDIS VAR. OCULUSIRIDIS	COSCINODISCUS RADIATUS	LIHODESMIUM CORNIGERUM	LIHODESMIUM MINUSCULUM	MELOSIRA SULCATA VAR. BISERIATA	MELOSIRA SULCATA VAR. CORONATA	MUELLERIELLA LIMBATA	NAVICULA LYRA VAR. EHRENBERGII	NAVICULA OPTIMA	NITZSCHIA CALIFORNICA	PERIPTERA TETRACLADIA	PSEUDOEUNOTIA DOLIOLUS	RHAPHONEIS AMPHICEROS VAR. ELONGATA	RHAPHONEIS AMPHICEROS VAR. GEMMIFERA	RHAPHONEIS FATULA	RHIZOSOLENIA BARBOI	RHIZOSOLENIA CF. R. ALATA	RHIZOSOLENIA HEBETATA	RHIZOSOLENIA STYLIFORMIS
73	X	●	X	X	X	X	X	/	X	0	X	X	/	X	X	0	/	/	/	/	X	X	/	X	0	/	X	X	X	/
72	X	●	/	X	X	/	X	/	0	X	X	0	X	X	/	X	·	X	·	·	·	/	/	/	X	X	/	·	X	·
71	0	●	/	X	/	X	·	·	/	X	/	0	X	X	/	X	·	·	·	X	·	·	·	/	X	·	·	/	X	·
70	·	0	·	·	/	/	·	·	·	/	X	X	/	X	·	X		·	·	·	/	/	·	0	·	·	X	·	X	·
69	X	/	·	/	·	·	·	/	/	/	X	0	/	0	X	/	·	·	·	/	·	·	·	X	·	·	·	·	·	·
68	·	·	X	/	X	X	/		X	·	·	X	·	0	X	·	X	·	·	·	·	·	·	·	/	·	·	·	·	·
67	·	/	/	/	/	·	/	·	X	·	·	X	·	X	X	·	X	X	X	·	·	X	·	·	·	·	·	·	·	·
66	/	X	/	X	·	·	/	·		·	·	0	·	●	/	·	·	·	·	X	·	/	·	·	X	·	/	/	X	·
65	·	·	/	·	/	/	·	·	/	/	·	●	X	●	/	X	·	·	·	X	·	·	·	·	·	·	/	·	/	·
64	·	·	·	·	·	/	/	·	·	/	X	0	·	●	/	·	·	/	/	·	·	/	·	/	·	·	X	·	/	·
63	·	·	X	·	X	·	·	·	/	X	X	X	X	·	X	·	/	·	·	/	·	/	·	·	·	·	/	·	·	·
62	X	·	/	·	/	X	·	·	/	X	/	·	/	·	X	·	·	/	·	·	·	·	·	·	/	·	·	·	X	·
61	·	·	/	/	·	/	·	·	·	·	X	X	/	0	X	·	/	·	/	·	·	/	·	·	X	·	/	·	/	X
60	/	·	X	X	X	0	·	X	·	X	0	0	·	0	X	X	·	·	·	/	·	·	·	·	X	·	X	·	/	·
59	·	·	/	·	·	0	X	·	·	/	/	0	X	0	X	X	·	·	·	/	·	·	·	·	/	·	·	·	/	·
58	·	·	/	·	·	/	0	/	·	X	X	X	X	0	X	/	·	·	·	·	·	·	·	·	0	·	/	·	X	·
57	·	/	/	X	·	X	X	·	·	/	·	X	X	0	X	·	·	X	·	·	·	·	·	·	0	·	·	·	X	·
56	·	/	/	X	·	X	X	·	/	X	X	0	/	/	0	/	·	·	·	/	/	X	·	·	X	/	X	·	X	·
55	·	/	X	·	·	/	/	·	·	·	/	0	/	/	●	·	/	·	·	·	·	/	·	·	X	X	·	·	X	·
54	X	·	/	·	·	X	·	·	·	X	X	0	X	/	0	/	·	/	·	X	·	·	·	·	X	·	X	·	X	·
53	·	·	/	X	·	/	·	·	/	·	X	X	·	·	/	·	/	·	·	/	/	/	·	·	X	·	·	·	X	X
52	X	·	·	·	·	/	X	·	0	·	X	X	/	·	0	·	·	·	·	X	·	·	·	·	0	·	/	·	/	·
51	·	·	·	/	·	/	/	·	X	X	0	0	X	·	X	X	·	·	·	X	·	·	·	·	0	·	·	·	/	X
50	·	·	X	·	·	0	/	X	·	X	●	●	0	·	0	/	·	·	/	X	·	·	X	·	/	·	·	·	X	/
49	/	·	/	/	·	0	·	/	·	·	●	●	0	·	0	·	/	·	X	/	·	X	·	·	X	/	·	/	X	/
48	·	·	·	·	·	/	·	X	/	·	●	X	X	·	X	·	·	/	/	·	·	X	·	·	X	·	/	·	X	·
47	·	/	X	/	·	X	·	/	·	·	0	0	0	·	·	/	X	·	·	X	·	X	·	·	X	·	·	·	X	X
46	X	·	/	·	0	·	·	·	·	·	X	0	X	·	X	·	·	·	·	X	/	X	·	·	X	/	·	·	/	·
45	·	·	·	·	X	·	·	/	·	/	0	X	·	·	X	·	/	·	·	/	·	·	·	·	/	·	X	/	X	·
44	·	·	/	/	/	/	·	X	·	·	0	X	·	·	/	·	·	·	/	X	/	/	·	·	X	·	X	·	X	·
43	/	X	·	·	X	·	·	/	X	/	X	0	0	·	X	/	·	/	·	·	·	/	·	/	X	·	/	·	X	·
42	X	·	X	·	·	·	·	X	/	/	X	0	X	·	X	·	X	·	/	X	·	·	·	X	X	·	·	/	/	/
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	·	·	X	·	/	X	·	·	·	·	●	X	X	·	X	/	/	·	/	/	·	/	·	0	/	·	·	·	X	/

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Sample Number \ Taxa	STEPHANOPYXIS APPENDICULATA	STEPHANOPYXIS HORRIDUS	STEPHANOPYXIS TURRIS	THALASSIONEMA ANTIQUA	THALASSIONEMA NITZSCHIODES	THALASSIOSIRA ANTIQUA	THALASSIOSIRA GRAVIDA CF.T.FORMA FOSSILIS	THALASSIOSIRA OESTRUPII	THALASSIOSIRA ZABELINAE	THALASSIOTHRIX LONGISSIMA	BIDDULPHIA AURITA	COSCINODISCUS ANTIQUUS	COSCINODISCUS EXCENTRICUS VAR. LEASAREOLATUS	HEMIDISCUS CUNEIFORMIS	ACTINOPTYCHUS BISMARCKII	BIDDULPHIA TRIDENS	COSCINODISCUS SUBTILIS	NITZSCHIA FOSSILIS	ACTINOPTYCHUS CLEVEI	ACTINOPTYCHUS SPLENDENS VAR. HALIONYX	COCCONEIS COSTATA	COSCINODISCUS OCULUSIRIDIS VAR. BOREALIS	RHABDONEMA JAOPNICUM	ACTINOPTYCHUS STELLA VAR. CLEVEI	ACTINOCYCLUS EHRENBERGII VAR. TENELLA	RHAPHONEIS SACHALINENSIS	RHIZOSOLENIA PRAEBERGONII	XANTHIOPYXIS OVALIS	DENTICULOPSIS KAMTSCHATICA	TRICERATIUM ELEGANS
73	X	X	X	X	0	X	X	X	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
72	X	X	/	X	0	X	X	/	·	X	X	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
71	X	·	·	X	●	X	0	X	·	X	X	·	·	·	/	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·
70	·	/	X	0	●	0	0	X	/	X	·	·	·	·	/	·	/	·	/	/	/	/	X	·	·	·	·	·	·	·
69	·	·	·	·	·	X	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	X	·	/	·	·	·	·	·	·
68	·	·	·	/	·	/	·	/	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	/	X	/	/	·	·
67	·	·	·	/	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	/	·	/	/
66	·	·	/	/	0	/	·	·	·	/	X	·	·	/	·	·	/	·	·	·	·	X	·	·	·	·	·	·	·	·
65	·	/	/	X	0	X	/	/	·	·	·	·	/	·	/	·	X	·	·	·	/	X	·	·	/	0	·	·	·	·
64	X	·	/	●	0	●	·	·	/	·	·	·	·	·	·	X	·	·	·	·	·	/	·	·	·	X	/	·	·	·
63	·	·	X	·	X	·	X	·	·	/	·	X	·	·	/	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·
62	·	/	X	/	X	·	/	X	·	X	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	●	·	·	·	·
61	/	·	X	·	X	●	/	X	·	·	/	·	·	/	X	·	/	·	·	·	·	·	·	·	·	●	·	·	/	·
60	/	·	/	/	X	●	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	0	·	·	·	/
59	X	·	·	·	X	●	·	0	·	/	·	·	/	·	·	·	X	·	·	·	/	/	·	·	/	X	·	·	·	·
58	/	·	/	X	X	●	/	0	·	X	X	·	·	·	/	·	·	·	·	·	·	X	·	·	·	X	·	·	/	·
57	·	·	/	/	X	●	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	X	·	/	·	·
56	/	·	·	·	X	●	·	·	·	X	·	·	X	·	·	·	·	·	·	·	·	X	·	X	·	0	·	/	X	·
55	/	·	·	/	X	/	/	/	·	/	/	·	·	·	·	·	·	·	·	·	·	/	·	/	·	0	·	·	·	·
54	·	/	X	0	0	0	/	/	·	X	/	·	·	·	·	·	·	·	·	·	·	X	/	·	/	X	·	·	·	·
53	·	·	X	X	0	X	·	X	·	X	X	·	·	·	·	·	·	·	·	·	/	·	·	·	X	/	·	·	X	·
52	X	·	/	●	●	●	·	·	·	0	·	·	·	X	X	·	/	·	·	·	·	·	·	·	/	0	·	·	·	·
51	X	·	X	●	●	●	·	·	·	0	·	·	·	/	·	X	·	/	·	·	·	·	/	/	·	0	·	·	·	·
50	·	·	X	/	●	/	·	·	·	●	·	·	·	·	·	/	·	·	·	·	·	X	X	·	·	0	·	/	·	·
49	·	·	X	X	●	X	·	·	·	●	/	·	·	/	/	·	·	·	/	·	·	X	X	/	·	0	·	X	/	·
48	·	·	/	X	●	X	·	·	·	0	·	·	·	·	/	·	·	/	·	·	·	·	·	·	/	X	·	·	·	·
47	X	·	/	·	0	·	·	·	·	0	·	·	·	X	·	·	·	·	·	/	·	/	/	·	·	●	·	/	·	·
46	·	·	0	0	X	0	·	·	·	●	·	·	·	·	/	·	·	·	/	·	·	/	·	X	·	●	·	X	·	·
45	/	·	0	0	X	0	·	·	·	●	/	·	·	·	·	·	·	·	·	·	X	·	/	/	·	●	·	·	/	·
44	/	·	0	0	0	0	·	·	·	0	·	·	·	·	·	·	·	/	/	·	·	·	·	X	X	0	·	·	·	·
43	/	·	0	/	0	/	·	·	·	/	/	·	·	0	·	·	·	·	·	/	·	X	·	·	·	0	·	·	·	·
42	·	·	0	●	/	●	/	·	·	X	·	·	·	·	X	/	·	·	/	/	·	X	/	·	·	0	·	/	/	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	·	·	·	/	/	/	·	·	·	/	·	·	·	/	·	/	·	·	·	·	·	/	/	/	X	X	·	·	·	·

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Sample Number \ Taxa	XANTHIOPYXIS OBLONGA	ACTINOCYCLUS CUBITUS	ENDICTYA OCEANICA	NITZSCHIA ROLANDII	ACTINOCYCLUS ELLIPTICUS	ACTINOPTYCHUS VULGARIS VAR. MONICAE	DOSSETIA LACERA	NITZSCHIA REINHOLDII	ACTINOCYCLUS INGENS	AULACODISCUS CONCENTRICUS	COSCINODISCUS PLICATUS	DENTICULOPSIS HYALINA	ROSSIELLA PRAEPALEACEUS	THALASSIOSIRA NIDULUS	THALASSIOSIRA CF.T.DECIPIENS	THALASSIOSIRA CONVEXA	THALASSIOSIRA HYLINOPSIS	DENTICULOPSIS SEMINAE VAR. FOSSILIS	DIMEROGRAMMA SP.?	NITZSCHIA JOUSEAE	THALASSIOSIRA CF.T.PACIFICA	BIDDULPHIA AURITA VAR. OBTUSA	THALASSIOSIRA HYALINA	AULACODISCUS KITTONI	DENTICULOPSIS HUSTEDII	HERCOTHECA MAMILLARIS	COSCINODISCUS STELLARIS VAR. SYMBOLOPHORA	GRAMMATOPHORA MERLETTA	MELOSIRA CLAVIGERA	THALASSIOSIRA CONVEXA VAR. ASPINOSA
	0061	0062	0063	0064	0065	0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	0080	0081	0082	0083	0084	0085	0086	0087	0088	0089	0090
73	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
72	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
71	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
70	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
69	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
68	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
67	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
66	/	X	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
65	·	·	X	·	/	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
64	·	·	O	·	/	·	·	·	/	/	/	/	X	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
63	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
62	·	·	X	/	·	·	·	·	X	·	·	·	·	/	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·
61	·	·	/	·	·	·	·	X	·	·	·	·	·	·	·	·	/	/	/	/	/	·	·	·	·	·	·	·	·	·
60	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	/	/	·	·	·	·	·	·	·
59	·	/	·	·	/	·	·	·	/	·	·	·	·	·	·	/	X	·	X	·	·	·	·	/	/	·	·	·	·	·
58	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	X	X	/	X	·	·	·	·	·	·	/	·	·	·	·
57	·	·	/	·	·	·	·	X	·	·	·	·	·	/	·	X	X	·	·	/	·	·	·	·	·	·	X	/	/	/
56	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	/	/	·	O	·	·	·	·	·	·	/	/	X	/	·
55	·	/	X	X	·	·	·	X	/	·	·	·	·	·	X	·	·	·	X	·	·	·	/	·	O	·	·	·	/	·
54	·	X	/	/	·	·	·	·	/	·	·	·	·	·	·	/	X	·	·	·	·	·	·	X	X	·	·	·	·	·
53	·	·	·	·	/	·	/	/	·	·	·	/	·	·	·	·	X	·	·	/	·	·	/	·	/	·	/	·	·	·
52	·	·	·	X	·	·	X	·	X	·	·	·	·	·	·	·	/	·	·	·	·	X	·	·	·	·	·	X	·	·
51	·	·	/	·	·	·	/	·	X	·	·	·	·	/	/	/	/	·	/	·	·	/	·	·	·	/	·	·	·	/
50	/	·	X	·	X	·	·	·	O	·	·	·	·	·	·	·	/	·	·	·	/	·	·	·	·	·	/	/	·	·
49	·	·	·	·	·	·	/	/	X	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·
48	·	/	·	·	·	·	X	/	/	/	·	·	·	·	/	·	·	·	·	·	/	·	·	·	X	·	/	·	·	·
47	/	·	·	·	·	·	X	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·
46	·	·	·	/	·	·	·	X	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	/	·	·	X	·	X	/
45	/	/	/	/	·	·	·	X	O	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	/	·	·	·	/	X
44	/	·	·	X	/	·	X	O	X	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	X	·	·	·	/	X
43	·	·	/	·	·	·	·	O	X	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	X	·
42	/	X	/	X	·	O	/	O	·	/	·	/	·	·	/	·	/	·	·	·	/	/	·	·	X	·	/	·	·	/
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	X	·	·	·	·	/	X	·	X	·	·	/	/	X	·	·	·	·	·	·	·	·	·	·	X	·	·	/	O	·

Frequency Key

- ● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
- o = Common. 1 Specimen Within 2 Field of View.
- x = Few. 1 Specimen Per Traverse (2cm).
- / = Rare. Specimens Sparser Than 1 Per Traverse.
- Δ = Reworked.

Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Sample Number \ Taxa	THALASSIOSIRA NATIVA	THALASSIOSIRA SP.3	XANTHIOPYXIS SP.	LIHODESMIUM ASKETOGONIUM	RHAPHONEIS MIOCENICA	ACTINOCYCLUS EHRENBERGII VAR. ASTERISCUS	STRICTODISCUS CALIFORICUS	TRICERATIUM VALIDUM	COSCINODISCUS ASTEROMPHALUS	COSCINODISCUS ROBUSTUS VAR. INCRETUS	POSOSIRA GLACIALIS	COSCINODISCUS OBSCURUS	THALASSIOSIRA EXCENTRICA	ACTINOPTYCHUS SPLENDENS VAR. INCISA	COSCINODISCUS HIROSAKIENSIS	GLYPHODESMUS WILLIAMSONII	PSEUDOPYXILLA AMERICANA	ASTEROMPHALUS DARWINII	COSCINODISCUS NODULIFER	ENTOPYLA AUSTRALIS VAR. GIGANTEA	GLYPHODISCUS STELLATUS	HEMIAULUS POLYMORPHUS	ARACHNOIDISCUS ORNATUS VAR. MONTEREYANUS	AULACODISCUS MARGARITACEUS	AULISCUS CAELATUS	CLADOGRAMMA DUBUIM	NITZSCHIA MIOCENICA	PSEUDOPYXILLA DUBIA	STRICTODISCUS BURYANUS	CLADOGRAMMA CALIFORNICUM
	091	092	093	094	095	096	097	098	099	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
73	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
72	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
71	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
70	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
69	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
68	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
67	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
66	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
65	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
64	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
63	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
62	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
61	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
60	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
59	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
58	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
57	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
56	X	·	/	X	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
55	/	·	·	/	·	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
54	/	·	/	X	·	·	·	·	X	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
53	·	/	·	/	/	·	X	·	·	·	X	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
52	·	·	·	·	·	·	·	·	·	·	·	·	·	/	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·
51	·	·	·	X	·	·	·	/	O	·	·	X	X	·	·	X	·	/	/	/	/	/	·	·	·	·	·	·	·	·
50	·	·	·	X	·	·	·	·	X	·	X	/	/	X	·	·	·	·	/	·	·	·	/	/	/	/	/	/	/	·
49	·	·	/	O	·	·	·	·	X	·	·	·	/	·	·	/	/	·	/	·	·	·	·	/	·	·	·	X	/	/
48	·	·	X	X	·	·	·	·	X	·	/	·	·	·	·	·	/	·	·	/	/	X	·	·	/	/	·	/	·	·
47	/	·	X	X	·	·	·	·	O	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	/	·	·
46	X	·	X	/	·	O	·	·	/	·	·	X	X	·	/	·	/	·	·	·	·	·	·	·	·	·	/	/	·	X
45	·	·	/	·	·	●	·	/	·	·	·	/	·	/	·	/	X	·	·	·	·	·	·	·	·	·	·	X	/	·
44	·	·	X	/	·	O	·	·	/	·	·	·	/	·	·	·	/	/	/	·	·	·	·	·	·	/	·	/	X	·
43	/	·	/	·	·	●	·	·	X	·	·	/	·	·	·	/	/	·	·	·	·	·	·	X	·	·	·	/	X	/
42	·	·	X	X	·	X	/	·	X	·	·	·	/	·	·	·	/	·	/	/	/	X	/	·	·	·	/	X	X	/
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	/	·	/	·	·	·	X	·	X	/	·	/	/	·	X	X	·	·	/	X	·	/	/	·	·	·	·	X	●	/

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
O = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Sample Number \ Taxa	COCCONEIS DECIPIENS 121	MELOSIRA SULCATA VAR. SIBERICA 122	ROUXIA CALIFORNICA 123	SYNEDRA JOUSEANA 124	THALASSIOSIRA MIOCENICA 125	TRICERATIUM CONDECORUM 126	BIDDULPHIA SUBORBICULARIS 127	CHAETOCEROS SPECIES [SPORE] 128	COSCINODISCUS MONICAE 129	GRAMMATOPHORA ANGULOSA 130	STEPHANODISCUS SP. 131	STEPHANOGONIA POLYACANTHA 132	COSCINODISCUS VESTUSTISSIMUS 133	XANTHIOPYXIS N. SP. D 134	AULISCUS PUNCTATUS 135	COSCINODISCUS NITIDUS 136	HEMIDISCUS SIMPLICISSIMUS 137	ARACHNOIDISCUS EHRENBERGII 138	AULACODISCUS SIMPLEX 139	BIDDULPHIA RHOMBUS 140	STEPHANOGONIA HANZAWAE 141	THALASSIOSIRA PUNCTATA 142	THALASSIOSIRA SP.6 143	TRICERATIUM ARCTICUM 144	OPEPHORA SCHWARTZII 145	COSCINODISCUS KURZII 146	DENTICULOPSIS DIMORPHA 147	ENDICTYA ROBUSTUS 148	THALASSIOSIRA PRAECONVEXA 149	ACTINOCYCLUS ELLIPTICUS VAR. MORONENSIS 150
73	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
72	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
71	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
70	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
69	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
68	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
67	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
66	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
65	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
64	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
63	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
62	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
61	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
60	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
59	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
58	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
57	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
56	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
55	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
54	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
53	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
52	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
51	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
50	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
49	X	/	/	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
48	·	·	·	·	·	·	/	/	/	X	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
47	/	·	X	X	·	·	/	·	X	/	·	·	/	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
46	·	·	·	·	·	/	·	/	·	X	·	·	·	X	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·
45	·	·	·	/	·	·	·	X	/	·	·	·	·	/	·	/	·	/	/	/	/	/	/	/	·	·	·	·	·
44	·	·	/	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	/	·	·	·	·
43	·	·	·	·	/	·	·	·	·	/	·	·	·	/	·	/	·	·	·	·	·	·	·	·	/	/	Δ	/	/
42	·	·	·	X	/	·	·	/	X	·	·	/	·	X	·	·	·	/	·	·	·	·	/	/	·	·	·	X	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	/	X	·	/	·	/	·	·	X	·	·	·	/	●	/	/	·	/	/	/	·	·	·	·	·	/	·	/	/

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
○ = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart II
Sweeny Road Diatoms
First Appearance Datum

Sample Number \ Taxa	COSCINODISCUS TABULARIS VAR. EGREGIUS (151)	THALASSIONEMA HIROSAKIENSIS (152)	TRICERATIUM THUMII (153)	ACTINOCYCLUS TSUGARUENIS (154)	ARACHNOIDISCUS DECORUS (155)	AULISCUS CAELATUS VAR. CONSTRICTA (156)	CESTODISCUS PULCHELLUS VAR. MACULATUS (157)	COCCONEIS DIRUPTA VAR. TRIUMPHIS (158)	COSCINODISCUS BIRADIATUS (159)	COSCINODISCUS PILOSUS (160)	DIPLONEIS CRABRO (161)	ROUXIA YABEI (162)	STEPHANOPYXIS SPINOSSIMA (163)	TOTAL SPECIES PRESENT (164)
73	·	·	·	·	·	·	·	·	·	·	·	·	·	40
72	·	·	·	·	·	·	·	·	·	·	·	·	·	37
71	·	·	·	·	·	·	·	·	·	·	·	·	·	31
70	·	·	·	·	·	·	·	·	·	·	·	·	·	30
69	·	·	·	·	·	·	·	·	·	·	·	·	·	18
68	·	·	·	·	·	·	·	·	·	·	·	·	·	19
67	·	·	·	·	·	·	·	·	·	·	·	·	·	20
66	·	·	·	·	·	·	·	·	·	·	·	·	·	27
65	·	·	·	·	·	·	·	·	·	·	·	·	·	32
64	·	·	·	·	·	·	·	·	·	·	·	·	·	31
63	·	·	·	·	·	·	·	·	·	·	·	·	·	20
62	·	·	·	·	·	·	·	·	·	·	·	·	·	28
61	·	·	·	·	·	·	·	·	·	·	·	·	·	34
60	·	·	·	·	·	·	·	·	·	·	·	·	·	28
59	·	·	·	·	·	·	·	·	·	·	·	·	·	32
58	·	·	·	·	·	·	·	·	·	·	·	·	·	34
57	·	·	·	·	·	·	·	·	·	·	·	·	·	33
56	·	·	·	·	·	·	·	·	·	·	·	·	·	42
55	·	·	·	·	·	·	·	·	·	·	·	·	·	40
54	·	·	·	·	·	·	·	·	·	·	·	·	·	42
53	·	·	·	·	·	·	·	·	·	·	·	·	·	41
52	·	·	·	·	·	·	·	·	·	·	·	·	·	33
51	·	·	·	·	·	·	·	·	·	·	·	·	·	48
50	·	·	·	·	·	·	·	·	·	·	·	·	·	48
49	·	·	·	·	·	·	·	·	·	·	·	·	·	55
48	·	·	·	·	·	·	·	·	·	·	·	·	·	48
47	·	·	·	·	·	·	·	·	·	·	·	·	·	43
46	·	·	·	·	·	·	·	·	·	·	·	·	·	50
45	·	·	·	·	·	·	·	·	·	·	·	·	·	55
44	·	·	·	·	·	·	·	·	·	·	·	·	·	51
43	·	·	·	·	·	·	·	·	·	·	·	·	·	54
42	/	/	/	·	·	·	·	·	·	·	·	·	·	78
41	·	·	·	·	·	·	·	·	·	·	·	·	·	0
40	·	·	·	·	·	·	·	·	·	·	·	·	·	0
39	/	/	/	/	X	/	/	/	/	●	/	/	/	82

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
○ = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart III
Sweeny Road Diatoms
Last Appearance Datum

Sample Number \ Taxa	C001 ACTINOCYCLUS EHRENBERGII	C002 ACTINOCYCLUS EHRENBERGII VAR. TENELLA	C003 ACTINOCYCLUS ELLIPTICUS VAR. MORONENSIS	C004 ACTINOCYCLUS INGENS	C005 ACTINOCYCLUS OCULATUS	C006 ACTINOCYCLUS TSUGARUENIS	C007 ACTINOPTYCHUS STELLA VAR. CLEVEI	C008 ACTINOPTYCHUS UNDULATUS	C009 ACTINOPTYCHUS VULGARIS VAR. MONICAE	C010 ARACHNOIDISCUS DECORUS	C011 ARACHNOIDISCUS EHRENBERGII	C012 ARACHNOIDISCUS ORNATUS VAR. MONTEREYANUS	C013 AULACODISCUS SIMPLEX	C014 AULISCUS CAELATUS VAR. CONSTRICTA	C015 AULISCUS PUNCTATUS	C016 BIDDULPHIA RHOMBUS	C017 BIDDULPHIA TRIDENS	C018 CESTODISCUS PULCHELLUS VAR. MACULATUS	C019 CLADOGRAMMA CALIFORNICUM	C020 COCCONEIS DECIPIENS	C021 COCCONEIS DIRUPTA VAR. TRIUMPHIS	C022 COSCINODISCUS ASTEROMPHALUS	C023 COSCINODISCUS BIRADIATUS	C024 COSCINODISCUS HIROSAKIENSIS	C025 COSCINODISCUS KURZII	C026 COSCINODISCUS MARGINATUS	C027 COSCINODISCUS MONICAE	C028 COSCINODISCUS NITIDUS	C029 COSCINODISCUS NODULIFER	C030 COSCINODISCUS OBSCURUS
73	X	·	·	·	X	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
72	/	·	·	·	X	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
71	/	·	·	·	/	·	·	X	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	/	·	·	·
70	·	·	·	·	/	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
69	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
68	X	/	·	·	X	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
67	/	/	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
66	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
65	/	/	·	·	/	·	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
64	·	·	·	/	·	·	·	/	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	X	·	·	·
63	X	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
62	/	·	·	X	/	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·
61	/	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
60	X	/	·	·	X	·	·	O	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	O	·	·	·
59	/	/	·	/	·	·	·	O	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·
58	/	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
57	/	·	·	·	·	·	X	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
56	/	·	·	·	·	·	X	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
55	X	·	·	/	·	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·
54	/	/	·	/	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	X	·	·	·
53	/	X	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	/
52	·	/	·	X	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	X	·	·	·
51	·	·	·	X	·	·	/	/	·	·	·	·	·	·	·	·	X	·	·	·	·	·	O	·	·	O	·	/	X
50	X	·	·	O	·	·	·	O	·	·	·	/	·	·	·	·	/	·	·	·	·	·	X	·	·	●	·	/	/
49	/	·	·	X	·	·	/	O	·	·	·	·	·	·	·	·	·	·	/	X	·	·	X	·	·	●	·	/	·
48	·	/	·	/	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	●	/	·	·
47	X	·	·	/	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	/	·	·	O	·	·	O	X	·	·
46	/	·	·	·	O	·	X	·	·	·	·	·	·	·	/	·	·	·	X	·	·	/	·	/	·	X	·	/	·
45	·	·	·	O	X	·	/	·	·	·	/	·	/	·	·	/	·	·	·	·	·	·	·	·	·	O	/	/	·
44	/	X	·	X	/	·	X	/	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	O	/	·	/
43	·	·	·	X	X	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	X	·	·	/	X	·	/	·
42	X	·	/	·	·	·	·	·	O	·	/	/	·	·	·	·	/	·	/	·	·	X	·	·	·	X	X	·	/
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	X	X	/	X	/	/	/	X	/	X	/	/	/	/	/	/	/	/	/	/	/	X	/	X	/	●	X	/	/

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart III
Sweeny Road Diatoms
Last Appearance Datum

Sample Number \ Taxa	COSCINODISCUS OCULUSIRIDIS VAR. BOREALIS	COSCINODISCUS OCULUSIRIDIS VAR. OCULUSIRIDIS	COSCINODISCUS PILOSUS	COSCINODISCUS RADIATUS	COSCINODISCUS ROBUSTUS VAR. INCRETUS	COSCINODISCUS TABULARIS VAR. EGREGIUS	COSCINODISCUS VESTUSTISSIMUS	DENTICULOPSIS HUSTEDII	DENTICULOPSIS HYALINA	DIPLONEIS CRABRO	DOSSETIA LACERA	ENDICTYA ROBUSTUS	ENTOPYLA AUSTRALIS VAR. GIGANTEA	GLYPHODESMUS WILLIAMSONII	GRAMMATOPHORA MERLETTA	HEMIAULUS POLYMORPHUS	HEMIDISCUS CUNEIFORMIS	LIHODESMIUM MINUSCULUM	MELOSIRA CLAVIGERA	MELOSIRA SULCATA VAR. BISERIATA	MELOSIRA SULCATA VAR. CORONATA	MELOSIRA SULCATA VAR. SIBERICA	NAVICULA LYRA VAR. EHRENBERGII	NAVICULA OPTIMA	PERIPTERA TETRACLADIA	PSEUDOPYXILLA DUBIA	RHABDONEMA JAOPNICUM	RHAPHONEIS AMPHICEROS VAR. ELONGATA	RHAPHONEIS AMPHICEROS VAR. GEMMIFERA	RHAPHONEIS SACHALINENSIS
	0031	0032	0033	0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047	0048	0049	0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060
73	·	X	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	0	/	·	/	/	X	·	·	X	0	·
72	·	0	·	X	·	·	·	·	·	·	·	·	·	·	·	·	/	/	·	X	·	·	·	·	/	·	·	/	X	·
71	·	0	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	X	·	·	·	X	·	·	·	/	X	·
70	/	X	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	/	·	X	0	·	·
69	X	0	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	/	·	·	·	/	·	·	·	X	·	·
68	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	X	·	·	·	·	·	·	·	/	X
67	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	X	·	X	·	X	·	·	·	·	·
66	X	0	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	/	·	·	·	·	·	X	/	·	·	·	X	·
65	X	●	·	X	·	·	·	·	·	·	/	·	·	·	·	·	·	/	·	X	·	·	·	X	·	·	·	·	·	0
64	/	0	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	/	·	·	·	·	/	·	/	·	·	/	·	X
63	·	X	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	/	·	·	/	/	·	·	·	·	X
62	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	X	X	·	·	·	·	·	·	·	·	·	·	/	●
61	·	X	·	/	·	·	·	·	·	·	·	·	·	·	·	·	/	X	·	·	/	·	/	·	/	·	·	·	X	●
60	·	0	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	X	·	·	·	/	·	·	·	·	X	0
59	/	0	·	X	·	·	·	/	·	·	·	·	·	·	·	·	·	X	·	X	·	·	·	/	·	·	·	·	/	X
58	X	X	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	/	·	·	·	·	·	·	·	·	0	X
57	·	X	·	X	·	·	·	·	·	·	·	·	·	·	/	·	·	X	/	·	·	·	·	·	·	·	·	·	0	X
56	X	0	·	/	·	·	·	·	·	·	·	·	·	·	X	·	·	0	/	/	·	·	·	/	X	·	·	·	X	0
55	/	0	·	/	·	·	·	0	·	·	·	·	·	·	·	·	·	●	/	·	/	·	·	·	/	·	·	·	X	0
54	X	0	·	X	/	·	·	X	·	·	·	·	·	·	·	·	·	0	·	/	·	·	·	X	·	·	/	·	X	X
53	·	X	·	·	·	·	·	·	/	·	/	·	·	·	/	·	·	/	·	·	/	·	·	/	/	·	·	·	X	/
52	·	X	·	/	·	·	·	·	·	·	X	·	·	/	·	·	X	0	X	·	·	·	·	X	·	·	·	·	0	0
51	·	0	·	X	·	·	·	·	·	·	/	·	/	X	·	/	/	X	·	X	·	·	·	X	·	·	/	·	0	0
50	X	●	·	0	·	·	·	·	·	·	·	·	·	·	/	·	·	0	/	/	·	·	/	X	·	/	X	·	/	0
49	X	●		0				X			/			/			/	0			/	/	X	/	X	X	X	·	X	0
48	·	X	·	X				X			X		/			X	·	X	·	·			/		X	/	·	·	X	X
47	/	0	·	0	·	·	/	·	·	·	X	·	·	/	·	·	X	·	·	/	X	·	·	X	X	/	/	·	X	●
46	/	0	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	X	X	·	·	·	·	X	X	/	·	·	X	●
45	·	X	·	·	·	·	·	/	·	·	·	·	·	/	·	·	·	X	/	·	/	·	·	/	·	X	/	·	/	●
44	·	X	·	·	·	·	·	X	·	·	X	·	·	·	·	·	·	/	/	·	·	·	/	X	/	/	·	·	X	0
43	X	0	·	0	·	·	·	/	·	·	·	/	·	/	·	·	0	X	X	/	·	·	·	·	/	/	·	/	X	0
42	X	0	·	X	·	/	·	X	/	·	/	X	/	·	·	X	·	X	·	·	X	·	/	X	·	X	/	X	X	0
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	/	X	●	X	/	/	/	X	/	/	X	/	X	X	/	/	/	X	0	/	/	X	/	/	/	X	/	0	/	X

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart III
Sweeny Road Diatoms
Last Appearance Datum

Sample Number \ Taxa	RHIZOSOLENIA HEBETATA	RHIZOSOLENIA STYLIFORMIS	ROSSIELLA PRAEPALEACEUS	ROUXIA YABEI	STEPHANOPYXIS SPINOSSIMA	STRICTODISCUS BURYANUS	STRICTODISCUS CALIFORICUS	SYNEDRA JOUSEANA	THALASSIONEMA ANTIQUA	THALASSIONEMA HIROSAKIENSIS	THALASSIONEMA NITZSCHIODES	THALASSIOSIRA ANTIQUA	THALASSIOSIRA EXCENTRICA	THALASSIOSIRA NATIVA	THALASSIOSIRA NIDULUS	THALASSIOSIRA PRAECONVEXA	THALASSIOTHRIX LONGISSIMA	TRICERATIUM CONDECORUM	TRICERATIUM THUMII	XANTHIOPYXIS N. SP. D	XANTHIOPYXIS OBLONGA	XANTHIOPYXIS SP.	ACTINOCYCLUS CHOLNOKYI	ACTINOCYCLUS CUBITUS	ACTINOCYCLUS EHRENBERGII VAR. ASTERISCUS	ACTINOPTYCHUS BISMARCKII	ACTINOPTYCHUS CLEVEI	ACTINOPTYCHUS SPLENDENS VAR. HALIONYX	AULACODISCUS CONCENTRICUS	BIDDULPHIA AURITA VAR. OBTUSA
	0061	0062	0063	0064	0065	0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079	0080	0081	0082	0083	0084	0085	0086	0087	0088	0089	0090
73	X	/	·	·	·	·	·	·	X	·	0	X	·	·	·	·	/	·	·	·	·	·	X	·	·	·	·	·	·	·
72	X	·	·	·	·	·	·	·	X	·	0	X	·	·	·	·	X	·	·	·	·	·	X	·	·	·	·	·	·	·
71	X	·	·	·	·	·	·	·	X	·	●	X	·	·	·	·	X	·	·	·	·	·	0	·	·	/	·	·	·	·
70	X	·	·	·	·	·	·	·	0	·	●	0	·	·	·	·	X	·	·	·	·	·	·	·	·	/	/	/	·	·
69	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·
68	·	·	·	·	·	·	·	·	/	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
67	·	·	·	·	·	·	·	·	/	·	·	/	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·
66	X	·	·	·	·	·	·	·	/	·	0	/	·	·	·	·	/	·	·	·	/	·	/	X	·	·	·	·	·	·
65	/	·	·	·	·	·	·	·	X	·	0	X	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·
64	/	·	X	·	·	·	·	·	●	·	0	●	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·
63	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	/	·	·	·	·	·	·	·	·	/	·	·	·	·
62	X	·	·	·	·	·	·	·	/	·	X	·	·	·	/	·	X	·	·	·	·	·	X	·	·	·	·	·	·	·
61	/	X	·	·	·	·	·	·	·	·	X	●	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·
60	/	·	·	·	·	·	·	·	/	·	X	●	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	/
59	/	·	·	·	·	·	·	·	·	·	X	●	·	·	·	·	/	·	·	·	·	·	·	/	·	·	·	·	·	·
58	X	·	·	·	·	·	·	·	X	·	X	●	·	·	·	·	X	·	·	·	/	·	·	/	·	/	·	·	·	·
57	X	·	·	·	·	·	·	·	/	·	X	●	·	/	/	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·
56	X	·	·	·	·	·	·	·	·	·	X	●	·	X	X	·	X	·	·	·	·	/	·	·	·	·	·	·	·	·
55	X	·	·	·	·	·	/	·	/	·	X	/	·	/	·	·	/	·	·	·	·	·	·	/	/	·	·	·	·	·
54	X	·	·	·	·	·	·	·	0	·	0	0	·	/	·	·	X	·	·	·	·	/	X	X	·	·	·	·	·	·
53	X	X	·	·	·	·	X	·	X	·	0	X	/	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·
52	/	·	·	·	·	·	·	·	●	·	●	●	·	·	·	·	0	·	·	·	·	·	X	·	·	X	·	·	·	·
51	/	X	·	·	·	·	·	·	●	·	●	●	X	·	/	·	0	·	·	·	·	·	·	·	·	·	·	·	·	·
50	X	/	·	·	·	/	·	·	/	·	●	/	/	·	·	·	●	·	·	·	/	·	·	·	·	·	·	·	·	·
49	X	/	·	·	·	/	·	/	X	·	●	X	/	·	/	·	●	/	·	·	·	/	/	·	·	/	/	·	·	·
48	X	·	·	·	·	·	·	·	X	·	●	X	·	·	·	·	0	·	·	·	·	X	·	/	·	/	·	·	/	·
47	X	X	·	·	·	·	·	X	·	·	0	·	·	/	·	·	0	·	·	X	/	X	·	·	·	·	·	/	·	·
46	/	·	·	·	·	·	·	·	0	·	X	0	X	X	X	·	●	/	·	X	·	X	X	·	0	/	/	·	·	·
45	X	·	·	·	·	/	·	/	0	·	X	0	·	·	/	·	●	·	·	/	/	/	·	/	●	·	·	·	·	·
44	X	·	·	·	·	X	·	·	0	·	0	0	/	·	·	·	0	·	·	·	/	X	·	·	0	·	/	·	·	·
43	X	·	·	·	·	X	·	·	/	·	0	/	·	/	·	/	/	·	·	/	·	/	/	·	●	·	·	/	/	·
42	/	/	·	·	·	X	/	X	●	/	/	●	/	·	·	·	X	·	/	X	/	X	X	X	X	X	/	/	/	/
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	X	/	/	/	/	●	X	/	/	/	/	/	/	/	X	/	/	/	/	●	X	/	·	·	·	·	·	·	·	·

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
o = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart III
Sweeny Road Diatoms
Last Appearance Datum

Sample Number \ Taxa	CHAETOCEROS CINCTUS	CHAETOCEROS DIADEMA	CHAETOCEROS DICLADIA	CHAETOCEROS SPECIES [SPORE]	COSCINODISCUS STELLARIS VAR. SYMBOLOPHORA	DENTICULOPSIS KAMTSCHATICA	ENDICTYA OCEANICA	GLYPHODISCUS STELLATUS	LIHODESMIUM ASKETOGONIUM	NITZSCHIA MIOCENICA	NITZSCHIA REINHOLDII	NITZSCHIA ROLANDII	PSEUDOPYXILLA AMERICANA	RHIZOSOLENIA CF. R. ALATA	STEPHANOGONIA POLYACANTHA	STEPHANOPYXIS TURRIS	THALASSIOSIRA CF.T.DECIPIENS	THALASSIOSIRA CONVEXA VAR. ASPINOSA	THALASSIOSIRA GRAVIDA CF.T.FORMA FOSSILIS	THALASSIOSIRA HYALINA	THALASSIOSIRA HYLINOPSIS	THALASSIOSIRA MIOCENICA	THALASSIOSIRA SP.6	TRICERATIUM ARCTICUM	XANTHIOPYXIS OVALIS	ACTINOCYCLUS CURVATULUS	AULISCUS CAELATUS	BIDDULPHIA AURITA	DENTICULOPSIS DIMORPHA	GRAMMATOPHORA ANGULOSA
	09 01	09 02	09 03	09 04	09 05	09 06	09 07	09 08	09 09	10 10	10 01	10 02	10 03	10 04	10 05	10 06	10 07	10 08	10 09	10 10	11 11	11 12	11 13	11 14	11 15	11 16	11 17	11 18	11 19	12 20
73	/	X	O	·	·	·	·	·	·	·	·	·	·	X	·	X	·	·	X	·	·	·	·	·	·	●	·	·	·	·
72	/	O	X	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	X	·	·	·	·	·	·	●	·	X	·	·
71	·	/	X	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	O	·	·	·	·	·	·	●	·	X	·	·
70	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	O	·	·	·	·	·	·	O	·	·	·	·
69	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	/	·	·
68	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·
67	·	X	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·
66	·	·	·	·	·	·	/	·	·	·	·	/	·	/	·	/	·	·	·	·	·	·	·	·	·	X	·	X	·	·
65	·	/	/	·	·	·	X	·	·	·	/	·	·	·	·	/	·	·	/	·	·	·	·	·	·	·	·	·	·	·
64	·	·	/	·	·	·	O	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·
63	·	/	X	·	·	·	X	·	·	·	·	·	·	·	·	X	·	·	X	·	·	·	·	·	·	·	·	·	·	·
62	·	/	X	·	·	·	X	·	·	·	·	/	·	·	·	X	/	·	/	·	/	·	·	·	·	·	·	·	·	·
61	·	·	·	·	·	/	/	·	·	·	X	·	·	·	·	X	·	·	/	·	/	·	·	·	·	·	·	/	·	·
60	X	·	X	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	/	/	·	·	·	·	·	·	·	·	·
59	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·
58	/	·	X	·	·	/	·	·	·	·	·	·	·	·	·	/	·	·	/	·	X	·	·	·	·	·	·	X	·	·
57	·	·	/	·	X	·	/	·	·	·	X	·	·	·	·	/	·	/	·	·	X	·	·	·	/	/	·	·	·	·
56	·	/	X	·	/	X	·	·	X	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	/	/	·	·	·	·
55	·	·	·	·	·	·	X	·	/	·	X	X	·	·	·	·	X	·	/	/	·	·	·	·	·	/	·	/	·	·
54	·	·	X	·	·	·	/	·	X	·	·	/	·	·	·	X	·	·	/	·	X	·	·	·	·	·	·	/	·	·
53	·	/	·	·	·	X	·	·	/	·	/	·	·	·	·	X	·	·	·	·	X	·	·	·	·	·	·	X	·	·
52	·	O	·	·	·	·	·	·	·	·	·	X	/	·	·	/	·	·	·	X	/	·	·	·	·	·	·	·	·	·
51	·	X	X	·	/	·	/	/	X	·	·	·	·	·	·	X	/	/	·	/	/	·	·	·	·	·	·	·	·	·
50	X	·	X	·	·	·	X	·	X	/	·	·	·	·	·	X	·	·	·	·	/	·	·	·	/	·	/	·	·	·
49	/	·	·	·	·	/	·	·	O	·	/	·	/	/	·	X	·	·	·	·	·	/	·	·	X	·	·	/	·	·
48	X	/	·	/	/	·	·	/	X	·	/	·	/	·	/	/	/	·	·	·	·	·	·	·	·	·	/	·	·	X
47	/	·	·	·	·	·	·	·	X	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	/	/	·	·	·	/
46	·	·	·	/	X	·	·	·	/	/	X	/	/	·	·	O	·	/	·	·	·	·	·	·	X	·	·	·	·	X
45	/	·	/	X	·	/	/	·	·	·	X	/	X	/	·	O	·	X	·	·	·	·	/	/	·	·	·	/	·	·
44	X	·	·	·	·	·	·	·	/	·	O	X	/	·	·	O	·	X	·	·	·	·	·	·	·	·	·	·	·	·
43	/	X	/	·	·	·	/	·	·	·	O	·	/	·	·	O	·	·	·	·	·	/	·	·	·	X	X	/	/	/
42	X	/	/	/	/	/	/	/	X	/	O	X	/	/	/	O	/	/	/	/	/	/	/	/	/	·	·	·	·	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
O = Common. 1 Specimen Within 2 Field of View.
X = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

Check Chart III
Sweeny Road Diatoms
Last Appearance Datum

Sample Number \ Taxa	MUELLERIELLA LIMBATA	OPEPHORA SCHWARTZII	RHIZOSOLENIA BARBOI	STEPHANOPYXIS APPENDICULATA	ACTINOCYCLUS ELLIPTICUS	ACTINOCYCLUS OCHOTENSIS	ASTEROMPHALUS DARWINII	CLADOGRAMMA DUBUIM	NITZSCHIA CALIFORNICA	NITZSCHIA FOSSILIS	ROUXIA CALIFORNICA	STEPHANOGONIA HANZAWAE	THALASSIOSIRA CONVEXA	ACTINOPTYCHUS SPLENDENS VAR. INCISA	COCCONEIS COSTATA	THALASSIOSIRA PUNCTATA	TRICERATIUM VALIDUM	AULACODISCUS KITTONI	HEMIDISCUS SIMPLICISSIMUS	RHAPHONEIS FATULA	BIDDULPHIA SUBORBICULARIS	POSOSIRA GLACIALIS	STEPHANODISCUS SP.	THALASSIOSIRA CF.T.PACIFICA	AULACODISCUS MARGARITACEUS	BACTERIASTRUM SP.	PSEUDOEUNOTIA DOLIOLUS	DIMEROGRAMMA SP.?	COSCINODISCUS SUBTILIS	HERCOTHECA MAMILLARIS
73	/	·	X	X	·	X	·	·	X	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	X	/	·	·	·
72	X	·	/	X	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	X	/	·	·	·
71	·	·	·	X	·	X	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·
70	·	·	X	·	·	·	·	·	/	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·
69	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
68	·	·	·	·	·	/	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·
67	X	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·
66	·	·	/	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	/	·
65	·	·	/	·	/	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	X	·
64	/	·	X	X	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·
63	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
62	/	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
61	·	·	/	/	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	/	/	·
60	·	·	X	/	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
59	·	·	·	X	/	·	·	·	·	·	·	·	/	·	/	·	·	/	·	·	·	·	·	·	·	X	·	X	X	·
58	·	·	/	/	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	O	·	X	·	/
57	X	·	·	·	·	X	·	·	·	·	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·
56	·	·	X	/	·	X	·	·	/	·	·	·	/	·	·	·	·	·	·	/	·	·	·	·	·	X	·	O	·	/
55	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	X	·	·	·	·	·	/	·	X	·	·
54	/	·	X	·	·	·	·	·	·	·	·	·	/	·	·	·	·	X	·	·	·	/	·	·	·	·	·	·	·	·
53	·	·	·	·	/	X	·	·	/	·	·	·	·	·	/	·	·	/	·	·	·	X	·	·	·	·	·	·	·	/
52	·	·	/	X	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	X	·	·	/	·
51	·	·	·	X	·	/	/	·	·	/	·	·	/	·	·	·	/	·	·	·	·	·	·	·	·	/	·	/	·	·
50	·	·	·	·	X	·	·	/	·	·	·	·	·	X	·	·	·	·	·	·	·	X	·	/	/	/	X	·	·	·
49	·	·	·	·	·	/	·	·	·	·	/	·	·	·	·	·	·	·	·	/	·	·	·	·	/	·	·	·	·	·
48	/	·	/	·	·	·	·	/	·	/	·	·	·	·	·	·	·	·	·	·	/	/	/	/	·	·	·	·	·	·
47	·	·	·	X	·	/	·	·	·	·	X	·	·	·	·	·	·	/	·	·	/	·	·	·	·	·	·	·	·	·
46	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	/	/	/	·	·	·	·	·	·	·	·	·	·
45	·	·	X	/	·	·	·	·	·	·	·	/	·	/	X	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·
44	·	/	X	/	/	/	/	/	/	/	/	X	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
43	/	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
42	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
39	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·

Frequency Key

- ● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
- o = Common. 1 Specimen Within 2 Field of View.
- x = Few. 1 Specimen Per Traverse (2cm).
- / = Rare. Specimens Sparser Than 1 Per Traverse.
- Δ = Reworked.

Check Chart III
Sweeny Road Diatoms
Last Appearance Datum

Sample Number \ Taxa	NITZSCHIA JOUSEAE 151	RHAPHONEIS MIOCENICA 152	THALASSIOSIRA OESTRUPII 153	THALASSIOSIRA SP.3 154	LIHODESMIUM CORNIGERUM 155	STEPHANOPYXIS HORRIDUS 156	COSCINODISCUS EXCENTRICUS VAR. LEASAREOLATUS 157	DENTICULOPSIS SEMINAE VAR. FOSSILIS 158	TRICERATIUM ELEGANS 159	COSCINODISCUS ANTIQUUS 160	COSCINODISCUS PLICATUS 161	RHIZOSOLENIA PRAEBERGONII 162	THALASSIOSIRA ZABELINAE 163	TOTAL SPECIES PRESENT 164
73	·	·	X	·	X	X	·	·	·	·	·	·	/	40
72	·	·	/	·	X	X	/	·	·	/	·	·	·	37
71	·	·	X	·	X	·	·	·	·	·	·	·	·	31
70	·	·	X	·	X	/	·	·	·	·	·	·	/	30
69	·	·	·	·	0	·	·	·	·	·	·	·	·	18
68	·	·	/	·	0	·	·	·	·	·	·	/	·	19
67	·	·	·	·	X	·	·	·	/	·	·	/	·	20
66	·	·	·	·	●	·	·	·	·	·	·	·	·	27
65	·	·	/	·	●	/	/	·	·	·	·	·	·	32
64	·	·	·	·	●	·	·	·	·	·	/	/	/	31
63	·	·	·	·	·	·	·	·	·	X	·	·	·	20
62	·	·	X	·	·	/	·	·	·	·	·	·	·	28
61	/	·	X	·	0	·	·	/	·	·	·	·	·	34
60	·	·	X	·	0	·	·	·	/	·	·	·	·	28
59	·	·	0	·	0	·	/	·	·	·	·	·	·	32
58	·	·	0	·	0	·	·	/	·	·	·	·	·	34
57	/	·	·	/	0	·	·	·	·	·	·	·	·	33
56	·	/	·	·	/	·	X	·	·	·	·	·	·	42
55	·	·	/	·	/	·	·	·	·	·	·	·	·	40
54	·	·	/	·	/	/	·	·	·	·	·	·	·	42
53	/	/	X	/	·	·	·	·	·	·	·	·	·	41
52	·	·	·	·	·	·	·	·	·	·	·	·	·	33
51	·	·	·	·	·	·	·	·	·	·	·	·	·	48
50	·	·	·	·	·	·	·	·	·	·	·	·	·	48
49	·	·	·	·	·	·	·	·	·	·	·	·	·	55
48	·	·	·	·	·	·	·	·	·	·	·	·		48
47	·	·	·	·	·	·	·	·	·	·	·	·		43
46	·	·	·	·	·	·	·	·	·	·	·	·		50
45	·	·	·	·	·	·	·	·	·	·	·			55
44	·	·	·	·	·	·	·	·	·					51
43	·	·	·	·	·	·	·	·	·					54
42	·	·	·	·	·	·	·	·						78
41	·	·	·	·	·	·	·							0
40	·	·	·	·	·	·	·	·						0
39	·	·	·	·	·	·	·							82

Frequency Key

● = Abundant. 2 or More Specimens Within 1 Field of View at X400.
○ = Common. 1 Specimen Within 2 Field of View.
x = Few. 1 Specimen Per Traverse (2cm).
/ = Rare. Specimens Sparser Than 1 Per Traverse.
Δ = Reworked.

PART IV
SILICOFLAGELLATES

R. E. MAROLT

CONTENTS

I. INTRODUCTION 85
II. SYSTEMATIC PALEONTOLOGY 85

ILLUSTRATIONS

PLATES 1-8 . . . . . beginning on page 86
CHECK CHART I, Silicoflagellates (alphabetized) 96
CHECK CHART II, Silicoflagellates (last appearance datum) 98
CHECK CHART III, Silicoflagellates (first appearance datum) 100

I. INTRODUCTION

Silicoflagellates constitute a minor yet important microscopic component of diatomaceous deposits of the Monterey Formation and superjacent Sisquoc Formation. The purpose of this study is to identify and document the silicoflagellate floral succession found in the Miocene-Pliocene interval of highly siliceous rocks exposed at Sweeny Road, Santa Barbara County, California.

Siliceous microfossils (diatoms, radiolarians, silicoflagellates, and ebridians) serve as the only means to subdivide biostratigraphically the Sweeny Road exposure, as this section is barren of all calcareous microfossils (i.e., benthic foraminifers and calcareous nannofossils). The silicoflagellates are treated herein and the diatoms and radiolarians are documented and discussed in Parts II and III, respectively.

This report represents the first formal documentation of the diverse silicoflagellate flora in the outcrops along Sweeny Road. Previous investigations of silicoflagellates in this area are restricted to studies of the Manville Quarry located approximately 4 mi. SW of the Sweeny Road section. These studies consist of an incidental documentation by J. A. Barron (1975) and a more complete analysis by L. D. Kourse (1980).

All illustrations were photographed at 800x using Polaroid Type 667 Land Film. Sample numbers are given for each figure.

II. SYSTEMATIC PALEONTOLOGY

Class SILICOFLAGELLATAE Borgert, 1890
Order SIPHONOTESTALES Lemmermann, 1901
Family DICTYOCHACEAE Lemmermann, 1901

Genus CANNOPILUS Haeckel, 1887

CANNOPILUS SPHAERICUS Gemeinhardt
Pl. 1, fig. 1

Cannopilus sphaericus Gemeinhardt, 1931, p. 104, pl. 10, fig. 3. 4. *fide* LOEBLICH *et al.*, 1968, p. 68, pl. 1. fig. 14, 15; LING, 1972, p. 149, 150, pl. 23. fig. 8-10.

CANNOPILUS sp. A
Pl. 1. fig. 4, 7

Remarks: This hexagonal (rarely pentheptagonal) form is distinguished by an apical structure that is divided into two or more openings. This structure is ornamented with minute spines that are randomly distributed and vary in number. In the Sweeny Road study material, this form was restricted to an interval between and including samples #45-63. Further investigation is necessary to determine its taxonomic classification.

CANNOPILUS sp. B
Pl. 1, fig. 10, 11

Remarks: This form possesses an elongate hexagonal basal ring that supports a divided apical ring. Two spines project distally from the apical system and are aligned along the major axis. The length and orientation of these spines distinguishes this form from C. sp. A.

Genus DICTYOCHA Ehrenberg, 1837

DICTYOCHA ASPERA CLINATA Bukry
Pl. 2, fig. 1, 2

Dictyocha sp. LING, 1972 (in part), p. 163, pl. 26, fig. 7, *non* fig. 4, 5, 6

Dictyocha sp. A LING, 1975, p. 772, pl. 1, fig. 20, 21
Dictyocha aspera clinata BUKRY, 1975b, p. 687, pl. 1, fig. 1-5; 1980, p. 380, pl. 2, fig. 4

DICTYOCHA BREVISPINA (Lemmermann) Bukry
Pl. 3, fig. 1, 2

Dictyocha fibula EHRENBERG, 1854 (in part), pl. 22, fig. 42a, b
Dictyocha fibula var. *brevispina* LEMMERMANN, 1901b, p. 260, figure cited from Ehrenberg, 1854
Dictyocha fibula var. *aspera* fa. *rhombica* SCHULZ, 1928, p. 253, fig. 37
Dictyocha ausonia DEFLANDRE, 1950, p. 195, fig. 194-196, 199-202
Dictyocha mutabilis DEFLANDRE, 1950, p. 197, fig. 203-208, 210, ?209
Dictyocha rhombica (Schulz) MARTINI, 1971 (in part), p. 1696, pl. 1, fig. 9, 10, *non* fig. 8; BUKRY, 1975b, pl. 4, fig. 5, 6

Remarks: Ehrenberg's (1854) *D. fibula* (pl. 21, fig. 42b) is omitted from this synonomy as it has been placed in synonomy with *D. pulchella* Bukry. *D. fibula* var. *brevispina* was raised in rank to the specific level by Bukry (1976a, p. 723).

DICTYOCHA COMPLEXA (Tsumura) Ling
Pl. 2, fig. 4

Dictyocha pseudofibula var. *complexa* TSUMURA, 1963, p. 56, 57, pl. 11, fig. 4, pl. 24, fig. 1
Dictyocha complexa (Tsumura) LING, 1977, p. 209, pl. 1, fig. 9, 10

Remarks: The original Latin description of this taxon by Tsumura (1963, p. 57) states "Basal ring est heptagonalis...". This description, however, is followed by the English translation "The basal ring is hexagonal...". This contraditction appears unintentional (the figured holotype is hexagonal) and the species concept followed herein is based on the English translation.

DICTYOCHA DELICATA (Bukry) Bukry var. BISECTA Bukry
Pl. 1, fig. 8

Dictyocha delicata (Bukry) Bukry var. *bisecta* BUKRY, 1982, p. 432, pl. 2, fig. 3-6

Remarks: Sweeny Road specimens differ from *D. delicata* var. *bisecta* s. str. by possessing an apical bar, the thickness of which equals that of the basal ring and basal pikes that are small and indistinct. These forms are herein designated *D.* sp. cf. *D. delicata* var. *bisecta*.

DICTYOCHA FIBULA Ehrenberg
Pl. 3, fig. 3, 5

Dictyocha fibula Ehrenberg, 1839, *fide* LOEBLICH *et al.*, 1968, p. 90, pl. 9, fig. 7-12

Remarks: Several forms, that possess asymmetric strut pairs, previously assigned to this species group have been reassigned to other species and subspecies by contemporary authors (Bukry, 1985, pers. comm.). Further investigation of the Sweeny Road study material is necessary to identify these forms and establish their respective stratigraphic significance in the section.

DICTYOCHA FIBULA FIBULA (Ehrenberg) Bukry
Pl. 2, fig. 3

Dictyocha fibula Ehrenberg, 1839, *fide* LOEBLICH *et al.*, 1968 (in part), p. 90, pl. 9, fig. 9, 10, 12 *non* fig. 7, 8, 11
Dictyocha fibula fibula (Ehrenberg) BUKRY, 1978a, p. 697, pl. 2, fig. 1, 2

DICTYOCHA LONGISPINA (Lemmermann) Bukry
Pl. 1, fig. 9

Dictyocha fibula var. *longispina* LEMMERMANN, 1901b, p. 260, pl. 10, fig. 26
Dictyocha fibula Ehrenberg s.l., MARTINI, 1971 (in part), p. 1698, pl. 1, fig. 4, *non* fig. 5-7

PLATE 1
All Figures 800x

1. *Cannopilus spaericus* Gemeinhardt. #69.
2,3. *Dictyocha pentagona* A. 2 - #65. 3 - #68.
4,7. *Cannopilus* sp. A. - #45.
5,6. *Dictyocha pulchella* Bukry. 5 - #62. 6 - #61.
8. *Dictyocha* sp. cf. *D. delicata* (Bukry) Bukry var. *bisecta* Bukry. #72.
9. *Dictyocha longispina* (Lemmermann) Bukry. #63.
10,11. *Cannopilus* sp. B. 10 - #54. 11 - #52.

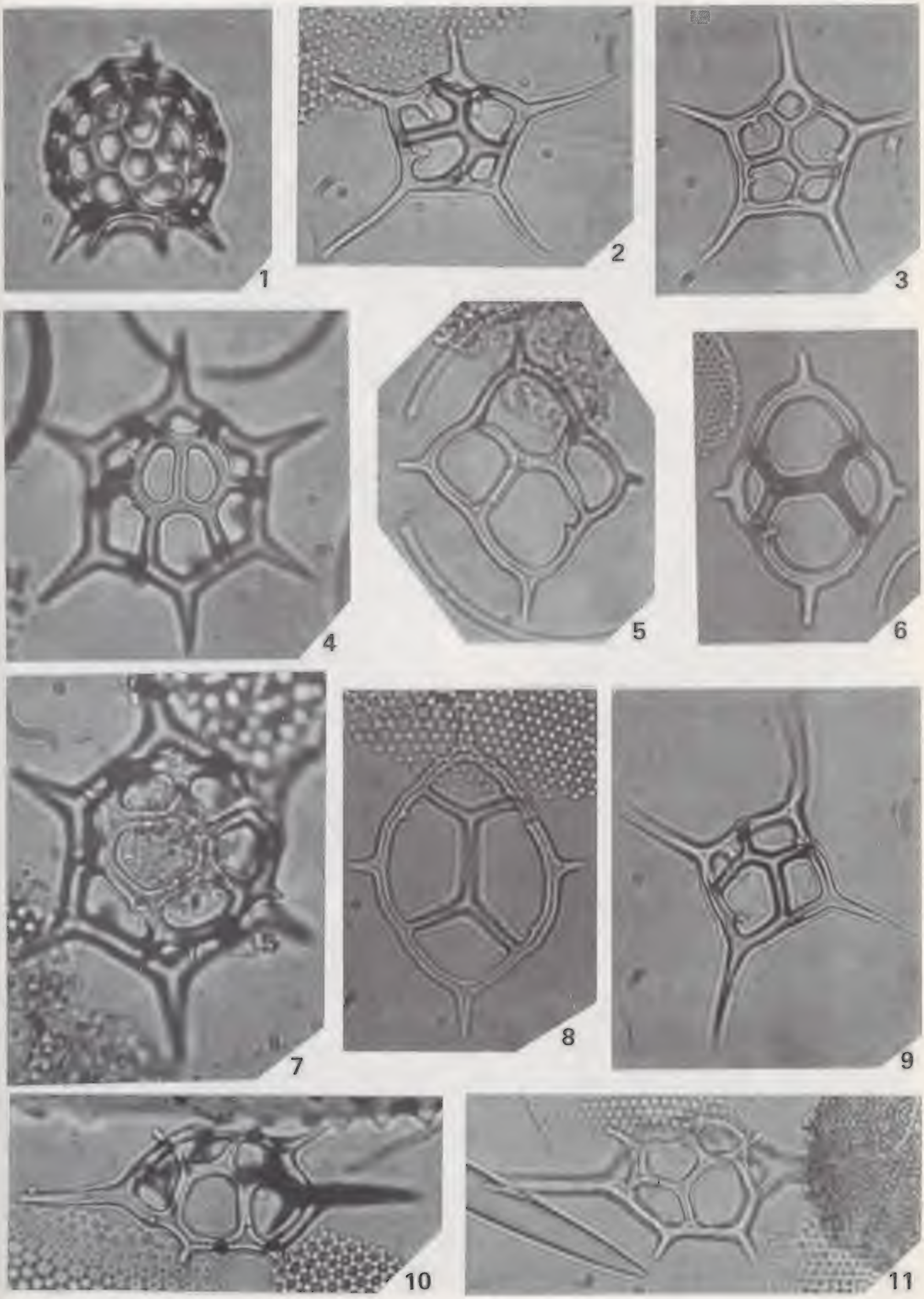


PLATE 1

Dictyocha fibula Ehrenberg, LING, 1975 (in part), p. 768, pl. 1, fig. 5, 6, *non* fig. 3, 4

Remarks: Bukry (1979a, p. 983) elevated this taxon to the specific level.

DICTYOCHA MEDUSA Haeckel
Pl. 3, fig. 4, 6

Dictyocha medusa HAECKEL, 1887, p. 1560, pl. 101, fig. 13, 14; BUKRY and FOSTER, 1973, p. 827, pl. 3, fig. 4, 5 (with description)

Remarks: A polyphyletic morphology of no use for long-range correlation (Bukry, 1985, pers. comm.).

DICTYOCHA PENTAGONA (Schulz) Bukry and Foster
Pl. 1, fig. 2, 3; Pl. 2, fig. 5, 8

Dictyocha fibula var. *pentagona* SCHULZ, 1928, p. 255, fig. 41a, b

Dictyocha pentagona (Schulz) BUKRY and FOSTER, 1973, p. 827, pl. 3, fig. 10 (with description)

Remarks: Two forms attributable to *D. pentagona* were observed in the Sweeny Road study material, herein designated as *D. pentagona* A and B. *D. pentagona* A is smaller form (approximately 30 micron basal ring maximum internal diameter) and may have been derived from *D. longispina* as is suggested by its stratigraphic relationship with the latter, quadrate form at Sweeny Road. *D. pentagona* B is a larger form (approximately 45 micron maximum internal diameter) and is similar to *Distephanus boliviensis boliviensis* in the manner indicated by Bukry (1976b, p. 894). *D. pentagona* B occurs in low frequency in an interval where *D. boliviensis boliviensis* has its greatest abundance, further suggesting an affinity between these two taxa or the environmental conditions which contributed to their formation (Bukry, 1985, pers. comm.).

DICTYOCHA PULCHELLA Bukry
Pl. 1, fig. 5, 6

Dictyocha fibula EHRENBERG, 1854 (in part), pl. 21 fig. 42b

Dictyocha fibula Ehrenberg, BACHMANN and ICHIKAWA, 1962 (in part), p. 169, pl. 2, fig. 30, pl. 7, fig. 10-14, *non* pl. 2, fig. 24-29, 31-33

Dictyocha fibula fibula rhombica Schulz GLEZER, 1966 (in part), p. 267, pl. 15, fig. 4 ?7, *non* fig. 5, 9

Dictyocha sp. LING, 1972 (in part), p. 163, pl. 26, fig. 4-6, *non* fig. 7, 8

Dictyocha cf. *aspera* Lemmerman, DUMITRICĂ, 1973a (in part), p. 907, pl. 7, fig. 4, 6, 7, *non* pl. 3, fig. 8, pl. 4, fig. 5-7, pl. 7, fig. 5

Dictyocha lingi Dumitrică, DUMITRICĂ, 1973 (in part), p. 848, pl. 3, fig. 4, *non* fig. 5-7

Dictyocha fibula ssp. *aspera* Lemmermann, DUMITRICĂ, 1973b (in part), p. 848, pl. 2, fig. 4-7, 11, ?12-13, *non* fig. 8-10, 15, 16

Dictyocha aspera (Lemmermann) BUKRY, 1973, p. 826, pl. 1, fig. 3

Dictyocha aspera (Lemmermann) s. ampl., BUKRY, 1975a, pl. 1, fig. 9, 10

Dictyocha pulchella BUKRY, 1975b, p. 687, pl. 4, fig. 1-3; BUKRY, 1978b, p. 816, pl. 2, fig. 12-16

Genus DISTEPHANUS Stöhr, 1880

DISTEPHANUS BOLIVIENSIS (Frenguelli) Bukry and Foster
Pl. 4, fig. 1-3, 6

Dictyocha boliviensis Frenguelli, 1940, p. 44, fig. 4, *fide* LOEBLICH *et al.*, 1968 (in part), p. 83, pl. 9, fig. 3, *non* fig. 4-6

Distephanus boliviensis (Frenguelli) BUKRY and FOSTER, 1973 (in part), p. 827, pl. 4, fig. 1, 2, *non* fig. 3

Remarks: Specimens observed in the Sweeny Road study material that resemble fig. 3 in Bukry and Foster (1973) were tabulated as *D. polyactis*. Samples #60-62, 64 and 66 contain large heptagonal specimens that have been designated *D.* sp. cf. *D. boliviensis*.

PLATE 2
All Figures 800x

1,2. *Dictyocha aspera clinata* Bukry. 1 - #63. 2 - #67.
3. *Dictyocha fibula fibula* (Ehrenberg) Bukry. #47.
4. *Dictyocha complexa* (Tsumura) Ling. #62.
5,8. *Dictyocha pentagona* B. 5 - #60. 8 - #65.
6,7. *Distephanus pseudofibula* (Schulz) Bukry. 6 - #66. 7 - #55.

PLATE 2

DISTEPHANUS CRUX PARVUS (Bachmann) Bukry
Pl. 4, fig. 4

Dictyocha crux Ehrenberg fa. *parva* Bachmann *in* ICHIKAWA *et al.*, 1967 (in part), p. 156, pl. 4, fig. 14, 15, 19, 23?, 29-31, *non* fig. 16-18, 20-22, 24-28

non Distephanus parvus (Bachmann) BUKRY and FOSTER, 1973, p. 828, pl. 5, fig. 2, 3

Distephanus crux (Ehrenberg) BUKRY, 1978a (in part), p. 697, pl. 2, fig. 8, 9, *non* fig. 7

Distephanus crux (Ehrenberg) BUKRY, 1980a, p. 514, pl. 2, fig. 8

Distephanus crux (Ehrenberg) Haeckel subsp. *parvus* (Bachmann) BUKRY, 1982a, p. 433, pl. 4, fig. 7

Remarks: The assignment of this species to the genus *Distephanus* follows the philosophy of Haeckel (1887). This approach is also used with *Distephanus speculum bispicatus* and *D. speculum speculum* recovered in this section.

DISTEPHANUS FRUGALIS (Bukry) Bukry
Pl. 5, fig. 1, 2, 4, 7

Distephanus speculum (Ehrenberg), small apical ring, BUKRY, 1973, p. 828, pl. 2, fig. 11, pl. 3, fig. 1; MARTINI and MÜLLER, 1976 (in part), pl. 3, fig. 2, *non* pl. 3, fig. 1, 3, pl. 6, fig. 1, pl. 8, fig. 12

Distephanus boliviensis frugalis BUKRY, 1975b, p. 688, pl. 2, fig. 2-7 (with description); BARRON 1976, p. 60, pl. 3, fig. 25, 26

Distephanus frugalis (Bukry) BUKRY, 1979b, p. 561, pl. 3, fig. 5, 6

Remarks: During frequency tabulations, pentagonal forms were recorded independently as *D. frugalis* (pentagonal) in the manner of Barron (1976). Possible synonyms for the pentagonal form are as follows:

Distephanus speculum var. *pentagonus* Lemmermann, LING, 1973, p. 753, pl. 2, fig. 16, 17

Distephanus quinquangellus Bukry and Foster, LING, 1975, p. 772, pl. 2, fig. 3

DISTEPHANUS JIMLINGII (Bukry) Bukry
Pl. 6, fig. 1-7

Distephanus boliviensis jimlingii BUKRY, 1975b, p. 688, pl. 1, fig. 6, 7a, pl. 2, fig. 1

Distephanus jimlingii (Bukry) BUKRY, 1979b, p. 561, pl. 3, fig. 7-12

Remarks: Pentagonal specimens of *D. jimlingii* were tabulated independently as *D. jimlingii* (pentagonal) and exhibit a different stratigraphic distribution in the study material from Sweeny Road.

DISTEPHANUS LONGISPINUS (Schulz) Bukry and Foster
Pl. 4, fig. 5

Distephanus crux fa. *longispina* SCHULZ, 1928, p. 256, fig. 44

Distephanus longispinus (Schulz) BUKRY and FOSTER, 1973, p. 828, pl. 4, fig. 7, 8

DISTEPHANUS MESOPHTHALMUS (Ehrenberg) Dumitrică
Pl. 5, fig. 3

Dictyocha mesophthalma Ehrenberg, 1844a, p. 64, 80, *fide* LOEBLICH *et al.*, 1968, p. 103; EHRENBERG, 1854, pl. 22, fig. 43

Dictyocha crux Ehrenberg fa. *parva* Bachmann *in* ICHIKAWA *et al.*, 1967 (in part), p. 156, pl. 4, fig. 16?, 25-27, *non* pl. 4, fig. 14, 15, 17-24, 29-31

Distephanus parvus (Bachmann) BUKRY and FOSTER, 1973, p. 828, pl. 5, fig. 2, 3

Distephanus mesophthalmus (Ehrenberg) DUMITRICĂ, 1973b, p. 850, pl. 6, fig. 9, 10, 12, 13

Distephanus crux (Ehrenberg) LOCKER, 1974 (in part), p. 637, pl. 3, fig. 8, *non* fig. 10

DISTEPHANUS POLYACTIS (Ehrenberg) Deflandre
Pl. 4, fig. 7

Dictyocha polyactis Ehrenberg, 1839, p. 129, table, *fide* LOEBLICH *et al.*, 1968, p. 109. Figured by Ehrenberg, 1854, pl. 22, fig. 50

Distephanus polyactis (Ehrenberg) DEFLANDRE, 1932, p. 501, 502, fig. 40 (with description); BUKRY and FOSTER, 1973, p. 828, pl. 5, fig. 6, 7

PLATE 3
All Figures 800x

1,2. *Dictyocha brevispina* (Lemmermann) Bukry. #42.
3,5. *Distyocha fibula* Ehrenberg. 3 - #42. 5 - #57.
4,6. *Dictyocha medusa* Haeckel. #42.
7. *Distephanus* sp. A. #43.

PLATE 3

DISTEPHANUS PSEUDOFIBULA (Schulz) Bukry
Pl. 2, fig. 6, 7

Distephanus speculum fa. *pseudofibula* SCHULZ, 1928, p. 261, fig. 51a, b
Dictyocha pseudofibula (Schulz) TSUMURA, 1963, p. 55, pl. XI, fig. 1-3, pl. XXIV, fig. 2

Remarks: This taxon was transferred back into the genus *Distephanus* by Bukry (1976c, p. 848).

DISTEPHANUS SPECULUM BISPICATUS Bukry
Pl. 5, fig. 5

Distephanus speculum (Ehrenberg) DUMITRIĂ, 1973a (in part), p. 908, pl. 10, fig. 7, 11, pl. 12, fig. 1, *non* pl. 10, fig. 4-6, 9, 10, pl. 11, fig. 1-9, pl. 12, fig. 2-14
Distephanus speculum (Ehrenberg) Haeckel subsp. *bispicatus* BUKRY, 1928b, p.315, pl. 6, fig. 2-4 (with description)

DISTEPHANUS SPECULUM fa. CORONATA Schulz
Pl. 5, fig. 11

Distephanus speculum fa. *coronata* SCHULZ, 1928, p. 262, fig. 50; Bukry, 1983, p. 331, pl. 7, fig. 7

DISTEPHANUS SPECULUM MINUTUS (Bachmann) Bukry
Pl. 5, fig. 8

Dictyocha speculum fa. *minuta* Bachmann *in* ICHIKAWA *et al.*, 1967, p. 161., pl. 7, fig. 12-15
Distephanus minutus (Bachmann) BUKRY and FOSTER, 1973, p. 828, pl. 4, fig. 10, 11
Distephanus speculum minutus (Bachmann) BUKRY, 1976b, p. 895, pl. 8, fig. 1-3

DISTEPHANUS SPECULUM SPECULUM (Ehrenberg) Haeckel
Pl. 5, fig. 6

Dictyocha speculum Ehrenberg, 1839, p. 150, *fide* LOEBLICH *et al.*, 1968, p. 114-115; EHRENBERG, 1854, pl. 18, fig. 57, pl. 19, fig. 41, pl. 21, fig. 44, pl. 22, fig. 47

DISTEPHANUS STRADNERI (Jerković) Bukry
Pl. 7, fig. 1, 4

Dictyocha schauinslandii Lemmermann, STRADNER, 1961 (in part), p. 92, pl. 2, fig. 60, *non* fig. 61, 63, 64, 69
Dictyocha schauinslandii stradneri Jerković, 1965, p. 3, pl. 2, fig. 2, *fide* LOEBLICH *et al.*, 1968, p. 112, pl. 7, fig. 7, 8

Remarks: Bukry (1978, p. 698) recognized "no obvious affinity of this form to *D. schauinslandii*" and raised it from the subspecific to specific level.

DISTEPHANUS sp. A
Pl. 3, fig. 7

Remarks: This pentagonal form is unusually large with a proportionally small apical ring. The basal ring is slightly indented at the strut junctions and the radial spines are short to moderate and equant. Only fragmented specimens were observed in the Sweeny Road study material and are restricted to samples #43 and 44.

DISTEPHANUS sp. B
Pl. 7, fig. 2, 3, 6

Remarks: This cruxoid form is similar to *D. stradneri* but differs by the placement of one, typically two, long spines on an apical ring that is proportionally larger than *D. stradneri*. A single pentagonal specimen was also observed (Pl. 7, fig. 6). This form is restricted to samples #68, 69.

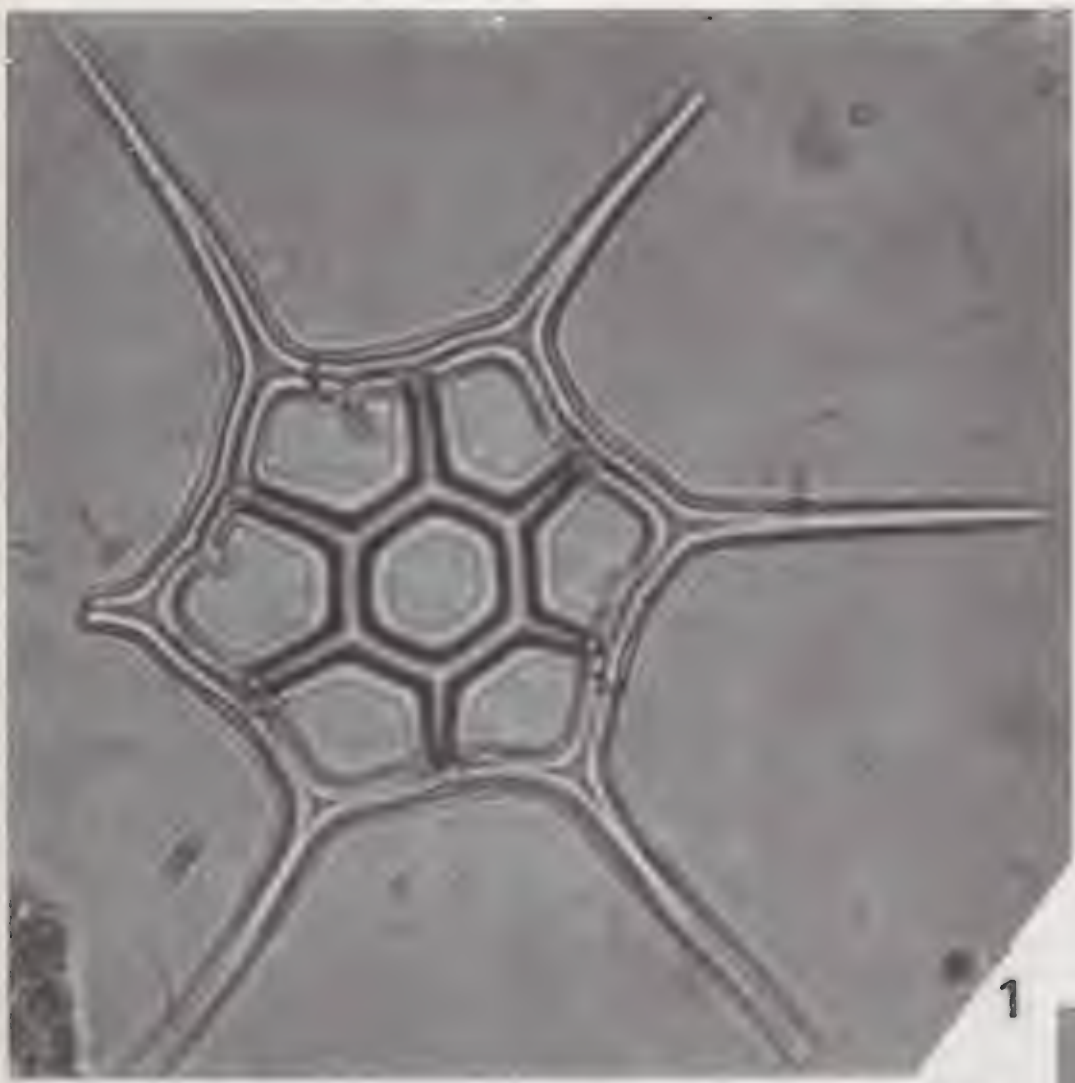
DISTEPHANUS sp. C
Pl. 7, fig. 5, 7, 8

Remarks: This distinct form is characterized by a hexagonal (rarely heptagonal) basal ring, short to moderate equant radial spines, moderate to highly indented basal ring at strut junctions, robust basal pikes and an asymmetric, subcircular apical ring. Cannopilean forms are rare and also included in this group. Probably related to *D. boliviensis*, this form occurs only in samples #59-61, #64-66 from Sweeny Road.

DISTEPHANUS sp. D
Pl. 5, fig. 9, 10

PLATE 4
All Figures 800x

1. *Distephanus boliviensis* (Frenguelli) Bukry. 1 - #62. 4 - #68.
2,6. *Distephanus* sp. cf. *D. boliviensis*. 2 - #62. 6 - #66.
4. *Distephanus crux parvus* (Bachmann) Bukry. #65.
5. *Distephanus longispinus* (Schulz) Bukry and Foster. #63.
7. *Distephanus polyactis* (Ehrenberg) Deflandre. #72.



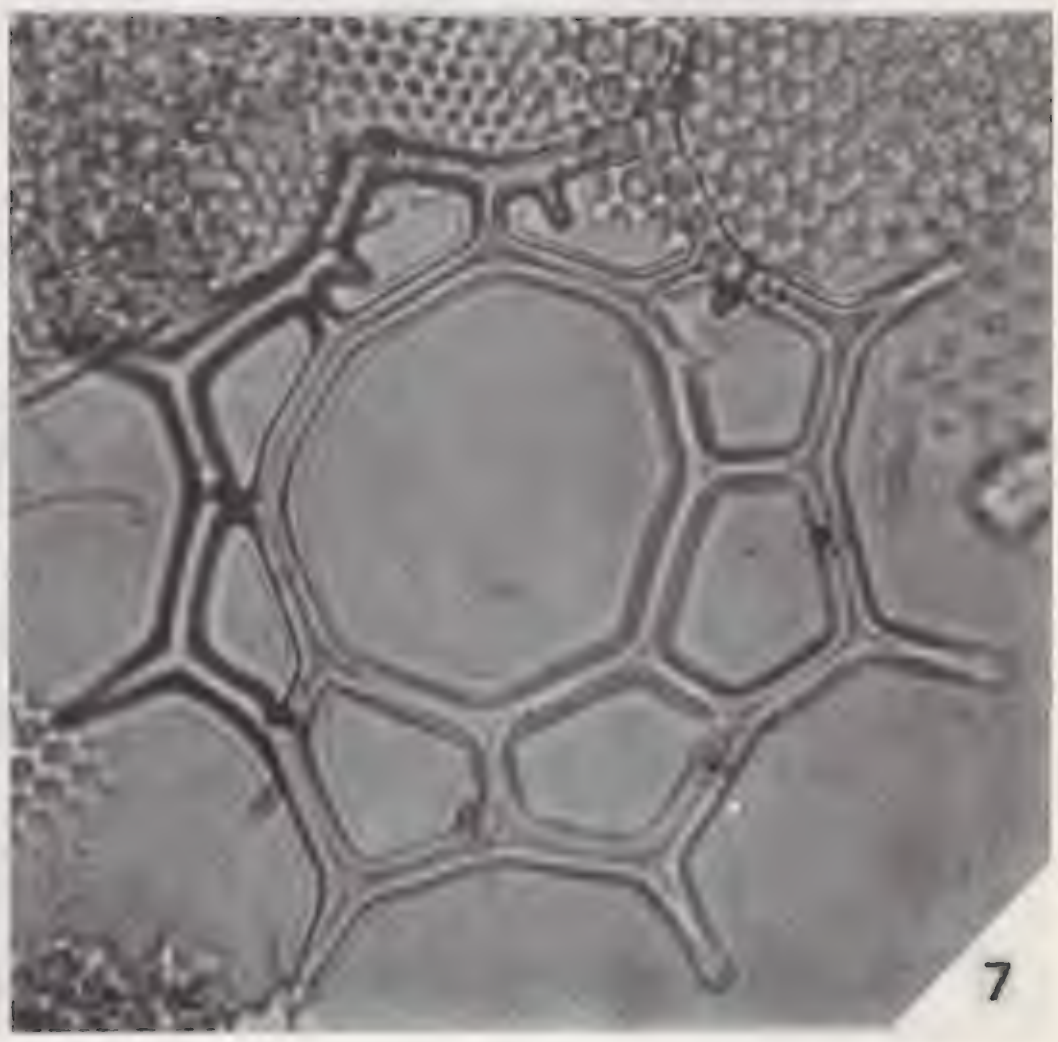


PLATE 4

Remarks: Distinguishing characteristics of specimens in this group are hexagonal (commonly pentagonal) basal ring, moderately sized equant radial spines, and a moderately sized (1/3 maximum internal diameter) asymmetric apical ring that is ornamented by small spines that vary in number. This form differs from *D.* sp. C by the spinose apical ring and slightly elongate basal ring.

Genus MESOCENA Ehrenberg, 1843

MESOCENA CIRCULUS (Ehrenberg) Ehrenberg
Pl. 8, fig. 1, 2

Dictyocha (Mesocena) circulus Ehrenberg, 1840b, p. 208, *fide* LOEBLICH *et al.*, 1968, p. 84; figured by Ehrenberg, 1854, p. 19, fig. 44, as *Mesocena*

Mesocena circula (Ehrenberg) BUKRY and FOSTER, 1973, p. 828, pl. 5, fig. 9, pl. 6, fig. 1 (with remarks)

Remarks: A highly sculpted, nodose form with irregularly placed spines is tabulated herein as *M.* sp. cf. *M. circulus*.

MESOCENA DIODON Ehrenberg s. ampl.
Pl. 8, fig. 4

Mesocena diodon Ehrenberg, 1844, p. 71, 84, *fide* LOEBLICH *et al.*, 1968, p. 128; EHRENBERG, 1854, pl. 33 (15), fig. 18

Mesocena diodon nodosa BUKRY, 1978b (in part), p. 818, pl. 5, fig. 14, 15, pl. 6, fig. 1-3, *non* fig. 4, 5

Mesocena diodon diodon Ehrenberg, BUKRY, 1978b, p. 818, pl. 5, fig. 9-13

Mesocena diodon borderlandensis BUKRY, 1981, p. 547, pl. 4, fig. 5-9, pl. 5, fig. 1, 2

MESOCENA ELLIPTICA (Ehrenberg) Ehrenberg
Pl. 8, fig. 3

Dictyocha (Mesocena) elliptica Ehrenberg, 1840, p. 208, *fide* LOEBLICH *et al.*, 1968, p. 89; EHRENBERG, 1854, pl. 20 (1), fig. 44a, b as *Mesocena*

Mesocena elliptica Ehrenberg, LOCKER, 1974, p. 634, pl. 2, fig. 4; Bukry, 1978b, p. 819, pl. 6, fig. 6-13

Remarks: For discussion, see Bukry (1978b)

MESOCENA HEXAGONA Haeckel
Pl. 8, fig. 5

Mesocena hexagona Haeckel, 1887, p. 1556; not figured, *fide* LOEBLICH *et al.*, 1968, p. 128; LING, 1977, p. 208, pl. 3, fig. 3

Remarks: This species may have close affinities to *M. hexalitha* (Bukry,1981, p. 547-548) but until resolved is retained in the older species assignment.

MESOCENA QUADRANGULA Ehrenberg *ex* Haeckel
Pl. 7, fig. 9

Mesocena quadrangula Ehrenberg *ex* HAECKEL, 1887, p. 1556; Lemmermann, 1901b, pl. 10, fig. 5-7, *fide* LOEBLICH *et al.*, 1968, p. 57, pl. 30, fig. 4-6; BUKRY, 1978b, p. 819, pl. 7, fig. 1-5

MESOCENA TRIANGULA (Ehrenberg) Ehrenberg
Pl. 8, fig. 6, 7

Dictyocha (Mesocena) triangula (Ehrenberg) 1844, p. 65, 71, *fide* LOEBLICH *et al.*, 1968, p. 118; EHRENBERG, 1854, pl. 22, fig. 41, as *Mesocena*

Mesocena polymorpha var. *triangula* (Ehrenberg) SCHULZ, 1928 (in part), p. 237, fig. 3a, *non* fig. 3b, c

?*Bachmannocena triangula* (Ehrenberg) LOCKER, 1974, p. 636, pl. 2, fig. 10 (lectotype)

Remarks: Forms identified as *M. triangula* (Ehrenberg) are present in the Sweeny Road study material together with forms tabulated as *M.* sp. cf. *M. triangula*. These latter forms differ by lacking the distinct symmetry of *M. triangula* s. str.

PLATE 5
All Figures 800x

1,2. *Distephanus frugalis* (Bukry) Bukry. #44.
3. *Distephanus mesophthalmus* (Ehrenberg) Dumitrică. #45.
4,7. *Distephanus frugalis* (Pentagonal)(Bukry) Bukry. 4 - #50. 7 - #70.
5. *Distephanus speculum* (Ehrenberg) Haeckel subsp. *bispicatus* Bukry. #68.
6. *Distephanus speculum speculum* (Ehrenberg) Haeckel. #43.
8. *Distephanus speculum minutus* (Bachmann) Bukry. #42.
9,10. *Distephanus* sp. D. 9 - #45 10 - #46
11. *Distephanus speculum* fa. *coronata* Schulz. #53.

PLATE 5

Check Chart I
Alphabetized Listing of Sweeny Road Silicoflagellates

Sweeny Road Silicoflagellates
(Alphabetized)

Sample Number \ Taxa	CANNOPILUS SP. A	CANNOPILUS SP. B	CANNOPILUS SPHAERICUS	DICTYOCHA ASPERA CLINATA	DICTYOCHA BREVISPINA	DICTYOCHA COMPLEXA	DICTYOCHA FIBULA	DICTYOCHA FIBULA FIBULA	DICTYOCHA LONGISPINA	DICTYOCHA MEDUSA	DICTYOCHA PENTAGONA A	DICTYOCHA PENTAGONA B	DICTYOCHA PULCHELLA	DICTYOCHA SP. CF. D. DELICATA VAR. BISECTA	DISTEPHANUS BOLIVIENSIS	DISTEPHANUS CRUX PARVUS	DISTEPHANUS FRUGALIS	DISTEPHANUS FRUGALIS (PENTAGONAL)	DISTEPHANUS JIMLINGII	DISTEPHANUS JIMLINGII (PENTAGONAL)	DISTEPHANUS LONGISPINUS	DISTEPHANUS MESOPHTHALMUS	DISTEPHANUS POLYACTIS	DISTEPHANUS PSEUDOFIBULA	DISTEPHANUS SP. A	DISTEPHANUS SP. B	DISTEPHANUS SP. C	DISTEPHANUS SP. CF. D. BOLIVIENSIS	DISTEPHANUS SP. D	DISTEPHANUS SPECULUM BISPICATUS	DISTEPHANUS SPECULUM F. CORONATA	DISTEPHANUS SPECULUM MINUTUS	DISTEPHANUS SPECULUM SPECULUM	DISTEPHANUS STRADNERI	MESOCENA CIRCULUS	MESOCENA DIODON S. AMPL.	MESOCENA ELLIPTICA	MESOCENA HEXAGONA	MESOCENA QUADRANGULA	MESOCENA SP. CF. M. CIRCULUS	MESOCENA SP. CF. M. TRIANGULA	MESOCENA TRIANGULA	TOTAL SPECIES PRESENT
73	·	·	/	X	/	/	/	·	·	·	/	·	·	/	X	/	●	/	/	·	/	/	/	·	·	·	·	·	/	0	·	·	·	X	/	/	·	·	·	·	·	20
72	·	·	·	0	·	·	/	·	·	·	/	·	·	/	X	·	●	/	X	·	/	·	/	/	·	·	·	·	·	0	·	·	/	/	/	·	/	·	·	·	·	16
71	·	·	·	/	/	·	·	·	·	·	/	·	·	·	/	·	●	/	/	·	/	·	·	/	·	·	·	·	·	0	·	·	/	X	·	/	·	·	·	·	·	13
70	·	·	/	/	·	/	/	·	·	·	/	/	·	·	/	·	●	/	X	·	/	·	·	·	·	·	·	·	·	0	·	/	·	·	·	/	·	·	·	·	·	14
69	·	·	/	·	·	/	/	·	·	·	·	/	/	·	/	·	●	/	/	·	/	·	·	/	·	/	·	·	·	0	/	·	/	·	/	/	·	·	·	·	·	17
68	·	·	/	/	·	·	·	·	·	·	0	·	·	·	X	/	●	·	/	·	/	·	·	·	·	/	·	·	/	0	·	/	/	·	·	·	/	·	·	·	·	15
67	·	·	/	X	·	/	/	·	·	·	·	·	/	·	X	·	0	/	·	·	/	·	·	/	·	·	·	·	/	/	/	·	/	/	·	·	/	·	·	·	·	15
66	·	·	/	/	·	·	·	·	/	·	/	·	·	/	0	·	●	/	/	·	/	·	/	/	·	·	/	/	·	/	·	·	·	·	/	·	·	·	·	·	·	16
65	·	·	·	0	/	/	/	·	/	·	/	/	/	·	●	/	X	/	/	/	/	·	·	/	·	·	/	·	0	X	·	·	/	/	/	·	·	·	·	·	/	23
64	·	·	·	/	·	·	/	·	/	·	·	·	/	·	X	·	/	/	/	·	/	·	·	·	·	·	/	/	/	0	·	·	/	/	·	·	·	·	·	·	/	16
63	/	·	/	/	/	·	·	·	/	·	·	·	/	·	/	·	/	·	·	·	/	·	·	/	·	·	·	·	·	●	·	·	/	/	·	·	·	·	·	·	·	13
62	/	·	·	/	/	/	·	·	/	·	·	/	/	·	0	·	0	/	/	/	X	·	·	/	·	·	·	/	·	0	0	X	·	/	/	·	/	/	·	·	·	22
61	·	/	·	0	/	·	/	/	/	·	·	/	/	·	0	·	/	·	/	·	·	·	·	/	·	·	/	/	·	●	·	0	/	/	·	·	·	·	·	·	·	18
60	/	·	·	/	·	·	/	/	/	·	·	/	·	·	/	/	·	/	/	·	·	·	·	/	·	·	X	/	·	●	0	/	·	/	·	·	·	·	·	·	·	17
59	·	/	/	/	·	·	/	/	/	·	·	·	·	·	●	/	/	·	/	·	X	·	·	/	·	·	/	·	/	X	·	·	·	·	·	·	·	·	·	·	·	16
58	/	·	·	·	·	·	/	·	/	·	·	·	/	·	/	/	/	·	/	/	/	·	·	/	·	·	·	·	/	●	·	·	/	X	·	·	/	·	·	·	·	16
57	/	/	/	●	·	·	/	/	/	·	·	/	/	·	/	/	/	X	·	·	/	·	·	/	·	·	·	·	/	0	·	·	/	X	/	·	·	·	·	·	·	20
56	/	/	/	/	/	·	/	·	·	·	·	·	·	·	/	/	/	/	·	·	/	·	·	/	·	·	·	·	/	X	·	0	/	/	/	·	/	·	·	·	·	20
55	/	·	/	●	·	/	/	·	/	·	·	·	·	·	/	·	·	/	·	·	/	·	·	/	·	·	·	·	·	0	0	·	/	/	/	·	/	·	·	·	·	16
54	/	/	·	X	/	·	/	·	/	·	·	·	·	·	0	·	/	X	●	/	/	·	·	/	·	·	·	·	/	0	0	/	/	/	·	·	/	·	·	·	·	20
53	·	·	/	/	·	·	·	·	/	·	·	·	·	·	/	·	·	·	●	·	·	·	·	/	·	·	·	·	/	·	/	/	·	·	/	·	·	/	·	·	·	11
52	/	/	·	●	·	·	/	·	/	·	·	·	·	·	/	/	/	/	/	·	/	·	·	/	·	·	·	·	·	/	·	·	·	/	/	·	·	·	·	/	·	16
51	/	·	·	/	·	·	·	/	/	·	·	·	·	·	/	/	/	/	·	·	·	·	·	/	·	·	·	·	·	/	/	·	/	/	/	·	·	·	·	·	·	14
50	/	·	·	0	·	·	/	·	·	·	·	·	·	·	X	·	·	/	●	·	·	·	·	·	·	·	·	·	/	·	X	/	·	·	·	/	·	·	·	·	·	10
49	/	·	·	/	·	/	/	·	/	·	·	·	·	·	/	·	·	X	·	X	/	/	·	·	·	·	·	·	0	/	●	0	/	·	/	/	·	·	·	/	/	19
48	/	·	/	·	·	·	/	·	/	·	·	·	·	·	·	/	/	●	·	0	/	·	·	/	·	·	·	·	X	·	/	X	/	/	/	/	·	/	·	·	/	20
47	·	·	·	/	/	·	·	/	X	·	·	·	·	·	0	·	0	X	·	X	/	/	·	·	·	·	·	·	/	/	●	/	/	·	/	·	·	·	·	·	·	16
46	/	·	·	●	·	·	X	·	/	·	·	·	·	·	X	·	0	●	·	X	·	●	·	/	·	·	·	·	0	/	●	/	X	/	/	·	·	·	·	·	·	16
45	/	·	·	X	·	·	/	·	/	·	·	·	/	·	X	·	/	0	/	X	/	0	·	/	·	·	·	·	●	·	●	/	/	/	·	/	·	·	·	·	·	19
44	·	·	·	/	/	·	●	·	/	·	·	·	/	·	X	·	0	X	/	·	/	·	·	·	/	·	·	·	/	X	●	/	/	/	·	/	·	·	·	·	·	18
43	·	·	·	/	/	·	0	·	X	·	·	·	/	·	X	·	●	X	·	·	·	·	·	/	/	·	·	·	·	●	0	/	●	·	/	/	·	·	·	/	·	17
42	·	·	·	/	/	·	X	·	/	/	·	·	/	·	/	·	/	X	·	·	/	·	·	·	·	·	·	·	·	/	●	●	/	·	/	/	·	/	/	/	·	20
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	0
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	0
39	·	·	/	X	·	·	●	·	·	/	·	·	·	·	0	·	0	·	/	·	/	·	·	·	·	·	·	·	·	/	●	/	X	/	/	·	/	·	·	·	·	15

Frequency Key

Symbol	Number of Specimens/ Horizontal Traverse of Slide (2x4 cm) @ 250X
●	>20
○	11–20
X	5–10
/	<5
Blank	0

PLATE 6
All Figures 800x

1,3,6. *Distephanus jimlingii* (Bukry) Bukry. 1 - #71. 3 - #50. 6 - #53.
2,4,5,7. *Distephanus jimlingii* (Pentagonal) (Bukry) Bukry. 2 - #65. 4 - #49. 5 - #65. 7 - #45.

PLATE 6

Check Chart II
Sweeny Road Silicoflagellates Arranged by First Appearance Upsection

Sweeny Road Silicoflagellates
(First Appearance)

Sample Number \ Taxa	CANNOPILUS SPHAERICUS	DICTYOCHA ASPERA CLINATA	DICTYOCHA FIBULA	DICTYOCHA MEDUSA	DISTEPHANUS BOLIVIENSIS	DISTEPHANUS FRUGALIS	DISTEPHANUS JIMLINGII	DISTEPHANUS LONGISPINUS	DISTEPHANUS SPECULUM BISPICATUS	DISTEPHANUS SPECULUM F. CORONATA	DISTEPHANUS SPECULUM MINUTUS	DISTEPHANUS SPECULUM SPECULUM	DISTEPHANUS STRADNERI	MESOCENA CIRCULUS	MESOCENA HEXAGONA	DICTYOCHA BREVISPINA	DICTYOCHA LONGISPINA	DICTYOCHA PULCHELLA	DISTEPHANUS FRUGALIS (PENTAGONAL)	MESOCENA DIODON S. AMPL.	MESOCENA QUADRANGULA	MESOCENA SP. CF. M. CIRCULUS	MESOCENA TRIANGULA	DISTEPHANUS PSEUDOFIBULA	DISTEPHANUS SP. A	DISTEPHANUS SP. D	CANNOPILUS SP. A	DISTEPHANUS JIMLINGII (PENTAGONAL)	DISTEPHANUS MESOPHTHALMUS	DICTYOCHA FIBULA FIBULA	DISTEPHANUS CRUX PARVUS	MESOCENA SP. CF. M. TRIANGULA	DICTYOCHA COMPLEXA	CANNOPILUS SP. B	DICTYOCHA PENTAGONA B	DISTEPHANUS SP. C	DISTEPHANUS SP. CF. D. BOLIVIENSIS	DICTYOCHA PENTAGONA A	DICTYOCHA SP. CF. D. DELICATA VAR. BISECTA	DISTEPHANUS POLYACTIS	DISTEPHANUS SP. B	MESOCENA ELLIPTICA	TOTAL SPECIES PRESENT
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
73	/	X	/	·	X	●	/	/	/	0	·	·	·	X	·	/	·	·	/	/	·	·	·	/	·	·	·	·	·	·	/	·	/	·	·	·	/	/	/	·	/	20
72	·	0	/	·	X	●	X	/	·	0	·	·	/	/	/	·	·	·	/	/	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	/	/	/	·	·	16
71	·	/	·	·	/	●	/	/	·	0	·	·	/	X	·	/	·	·	/	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	/	·	·	·	/	13
70	/	/	/	·	/	●	X	/	·	0	·	/	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	/	·	/	·	/	·	·	·	/	14
69	/	·	/	·	/	●	/	/	·	0	/	·	/	·	·	·	/	/	/	·	·	·	·	/	·	·	·	·	·	·	·	·	/	·	/	·	·	·	·	/	/	17
68	/	/	·	·	X	●	/	/	/	0	·	/	/	·	/	·	·	·	·	·	·	·	·	·	/	·	·	·	·	·	/	·	·	·	·	·	0	·	·	/	·	15
67	/	X	/	·	X	0	·	·	/	/	/	·	/	/	/	·	·	/	/	·	·	·	·	/	·	·	·	·	·	·	·	·	/	·	·	·	·	·	·	·	·	15
66	/	/	·	·	0	●	/	/	·	/	·	·	·	·	·	·	/	·	/	/	·	·	·	/	·	·	·	·	·	·	·	·	·	·	/	/	/	/	/	·	·	16
65	·	0	/	·	●	X	/	/	0	X	·	·	/	/	·	/	/	/	/	/	·	·	/	/	·	·	·	/	·	·	/	·	/	·	/	/	·	/	·	·	·	23
64	·	/	/	·	X	/	/	/	/	0	·	·	/	/	·	·	/	/	/	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	/	/	·	·	·	·	·	16
63	/	/	·	·	/	/	·	/	·	●	·	·	/	/	·	/	/	/	·	·	·	·	/	·	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	13
62	·	/	·	·	0	0	/	X	·	0	0	X	·	/	/	/	/	/	/	/	/	·	/	·	·	·	/	/	·	·	·	/	·	/	·	/	·	·	·	·	·	22
61	·	0	/	·	0	/	/	·	·	●	·	0	/	/	·	/	/	/	·	·	·	·	/	·	·	·	·	·	/	·	·	·	/	/	/	/	·	·	·	·	·	18
60	·	/	/	·	/	·	/	·	·	●	0	/	·	/	·	·	/	·	/	·	·	·	/	·	/	·	·	·	/	/	·	·	·	/	X	/	·	·	·	·	·	17
59	/	/	/	·	●	/	/	X	/	X	·	·	·	·	·	·	/	·	·	·	·	·	/	·	/	·	·	·	/	/	·	·	·	/	/	·	·	·	·	·	·	16
58	·	·	/	·	/	/	/	/	/	●	·	/	·	X	/	·	/	/	·	·	·	·	/	·	·	·	/	/	·	·	/	·	·	·	·	·	·	·	·	·	·	16
57	/	●	/	·	/	/	·	/	/	0	·	·	/	X	·	·	/	/	X	/	·	·	/	·	·	·	/	·	·	/	/	·	·	/	/	·	·	·	·	·	·	20
56	/	/	/	·	/	/	·	/	/	X	·	0	/	/	/	/	·	/	/	·	·	·	/	·	/	/	·	·	·	/	·	·	/	·	·	·	·	·	·	·	·	20
55	/	●	/	·	/	·	·	/	·	0	0	·	/	/	/	·	/	·	/	/	·	·	/	·	·	/	·	·	·	·	/	·	·	·	·	·	·	·	·	·	·	16
54	·	X	/	·	0	/	●	/	·	0	0	/	/	/	/	/	/	·	X	·	·	·	/	·	/	/	/	·	·	·	·	/	·	·	·	·	·	·	·	·	·	20
53	/	/	·	·	/	·	●	·	·	/	/	·	·	/	/	·	/	·	·	·	·	·	/	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	11
52	·	●	/	·	/	/	/	/	·	/	·	·	·	/	·	·	/	·	/	/	·	·	/	·	/	·	·	·	/	/	·	/	·	·	·	·	·	·	·	·	·	16
51	·	/	·	·	/	/	·	·	·	/	/	·	/	/	·	·	/	·	/	/	·	·	/	·	/	·	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·	14
50	·	0	/	·	X	·	●	·	·	X	/	·	·	·	·	·	·	·	/	/	·	·	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	10
49	·	/	/	·	/	·	·	/	/	●	0	/	·	/	·	·	/	·	X	/	·	/	·	·	0	/	X	/	·	·	/	/	·	·	·	·	·	·	·	·	·	19
48	/	·	/	·	·	/	·	/	·	/	X	/	/	/	/	·	/	·	●	/	·	·	/	·	X	/	0	/	·	/	/	·	·	·	·	·	·	·	·	·	·	20
47	·	/	·	·	0	0	·	/	/	●	/	/	·	/	·	/	X	·	X	·	·	·	·	·	/	·	X	/	/	·	·	·	·	·	·	·	·	·	·	·	·	16
46	·	●	X	·	X	0	·	·	/	●	/	X	/	·	·	·	/	·	●	·	·	·	/	·	0	/	X	●	·	·	·	·	·	·	·	·	·	·	·	·	·	16
45	·	X	/	·	X	/	/	/	·	●	/	/	/	·	·	·	/	/	0	/	·	·	/	·	●	/	X	0	·	·	·	·	·	·	·	·	·	·	·	·	·	19
44	·	/	●	·	X	0	/	/	X	●	/	/	/	·	/	/	/	/	X	/	·	·	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	18
43	·	/	0	·	X	●	·	·	●	0	/	●	·	/	·	/	X	/	X	/	·	/	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	17
42	·	/	X	/	/	/	·	/	/	●	●	/	·	/	/	/	/	/	X	/	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	20
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	0
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	0
39	/	X	●	/	0	0	/	/	/	●	/	X	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	15

Frequency Key

Symbol	Number of Specimens/ Horizontal Traverse of Slide (2x4 cm) @ 250X
●	>20
O	11–20
X	5–10
/	<5
Blank	0

PLATE 7
All Figures 800x

1,4. *Distephanus stradneri* (Jerković) Bukry. 1 - #48. 4 - #39.
2,3,6. *Distephanus* sp. B. 2 - #69. 3 - #69. 6 - #68.
5,7,8. *Distephanus sp. C.* 5 - #64. 7 - #59. 8 - #64.
9. *Mesocena quadrangula* Ehrenberg *ex* Haeckel. #62.

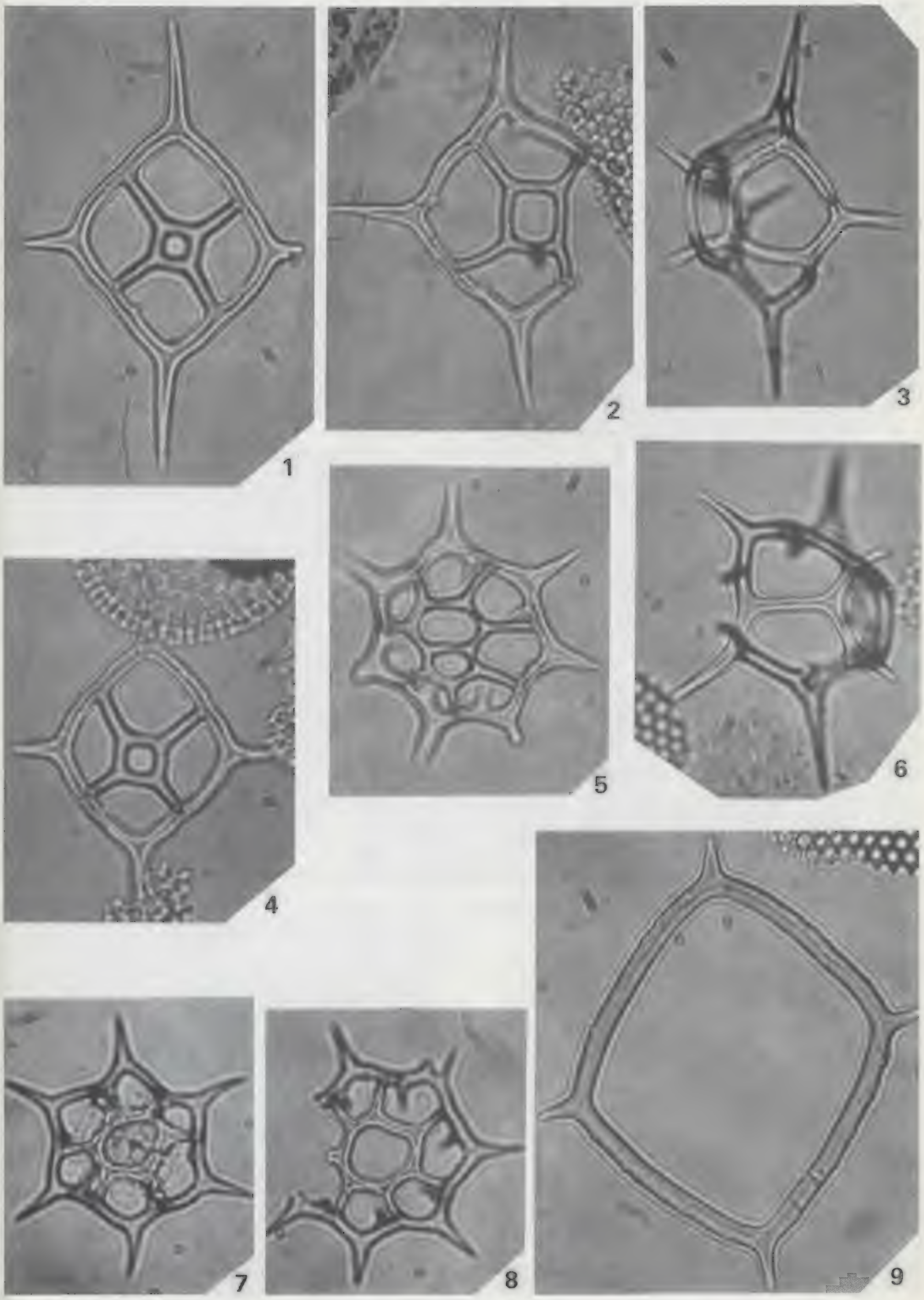


PLATE 7

Check Chart III
Sweeny Road Silicoflagellates Arranged by Last Appearance Upsection

Sweeny Road Silicoflagellates
(Last Appearance)

Sample Number / Taxa	CANNOPILUS SPHAERICUS	DICTYOCHA ASPERA CLINATA	DICTYOCHA BREVISPINA	DICTYOCHA COMPLEXA	DICTYOCHA FIBULA	DICTYOCHA PENTAGONA A	DICTYOCHA SP. CF. D. DELICATA VAR. BISECTA	DISTEPHANUS BOLIVIENSIS	DISTEPHANUS CRUX PARVUS	DISTEPHANUS FRUGALIS	DISTEPHANUS FRUGALIS (PENTAGONAL)	DISTEPHANUS JIMLINGII	DISTEPHANUS LONGISPINUS	DISTEPHANUS POLYACTIS	DISTEPHANUS PSEUDOFIBULA	DISTEPHANUS SPECULUM BISPICATUS	DISTEPHANUS SPECULUM F. CORONATA	MESOCENA CIRCULUS	MESOCENA DIODON S. AMPL.	MESOCENA ELLIPTICA	DISTEPHANUS STRADNERI	MESOCENA HEXAGONA	DICTYOCHA PENTAGONA B	DISTEPHANUS SPECULUM SPECULUM	DICTYOCHA PULCHELLA	DISTEPHANUS SP. B	DISTEPHANUS SPECULUM MINUTUS	DISTEPHANUS SP. D	DICTYOCHA LONGISPINA	DISTEPHANUS SP. C	DISTEPHANUS SP. CF. D. BOLIVIENSIS	DISTEPHANUS JIMLINGII (PENTAGONAL)	MESOCENA TRIANGULA	CANNOPILUS SP. A	MESOCENA QUADRANGULA	CANNOPILUS SP. B	DICTYOCHA FIBULA FIBULA	MESOCENA SP. CF. M. TRIANGULA	DISTEPHANUS MESOPHTHALMUS	DISTEPHANUS SP. A	MESOCENA SP. CF. M. CIRCULUS	DICTYOCHA MEDUSA	TOTAL SPECIES PRESENT
	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	4	4	4	4
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3
73	/	X	/	/	/	/	/	X	/	●	/	/	/	/	/	/	0	X	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	20
72	·	0	·	·	/	/	/	X	·	●	/	X	/	/	/	·	0	/	/	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	16
71	·	/	/	·	·	/	·	/	·	●	/	/	/	·	/	·	0	X	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	13
70	/	/	·	/	/	/	·	/	·	●	/	X	/	·	·	·	0	·	·	/	·	·	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	14
69	/	·	·	/	/	·	·	/	·	●	/	/	/	·	/	·	0	·	/	/	/	·	/	·	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	17
68	/	/	·	·	·	0	·	X	/	●	·	/	/	·	·	/	0	·	·	·	/	/	·	/	·	/	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	15
67	/	X	·	/	/	·	·	X	·	0	/	·	·	·	/	/	/	/	·	·	/	/	·	·	/	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	15
66	/	/	·	·	·	/	/	0	·	●	/	/	/	/	/	·	/	·	/	·	·	·	·	·	·	·	·	·	/	/	/	·	·	·	·	·	·	·	·	·	·	·	16
65	·	0	/	/	/	/	·	●	/	X	/	/	/	·	/	0	X	/	/	·	/	·	/	·	/	·	·	·	/	/	·	/	/	·	·	·	·	·	·	·	·	·	23
64	·	/	·	·	/	·	·	X	·	/	/	/	/	·	·	/	0	/	·	·	/	·	·	·	/	·	·	·	/	/	/	·	/	·	·	·	·	·	·	·	·	·	16
63	/	/	/	·	·	·	·	/	·	/	·	·	/	·	/	·	●	/	·	·	/	·	·	·	/	·	·	·	/	·	·	·	·	/	·	·	·	·	·	·	·	·	13
62	·	/	/	/	·	·	·	0	·	0	/	/	X	·	/	·	0	/	/	·	·	/	/	X	/	·	0	·	/	·	/	/	·	/	/	·	·	·	·	·	·	·	22
61	·	0	/	·	/	·	·	0	·	/	·	/	·	·	/	·	●	/	·	·	/	·	/	0	/	·	·	·	/	/	/	·	·	·	·	/	/	·	·	·	·	·	18
60	·	/	·	·	/	·	·	/	/	·	/	/	·	·	/	·	●	/	·	·	·	·	/	/	·	·	0	·	/	X	/	·	·	/	·	/	·	·	·	·	·	·	17
59	/	/	·	·	/	·	·	●	/	/	·	/	X	·	/	/	X	·	·	·	·	·	·	·	·	·	·	/	/	/	·	·	·	·	·	/	/	·	·	·	·	·	16
58	·	·	·	·	/	·	·	/	/	/	·	/	/	·	/	/	●	X	·	·	·	/	·	/	/	·	·	·	/	·	·	/	·	/	·	·	·	·	·	·	·	16
57	/	●	·	·	/	·	·	/	/	/	X	·	/	·	/	/	0	X	/	·	/	·	/	·	/	·	·	·	/	·	·	·	·	/	·	/	/	·	·	·	·	·	20
56	/	/	/	·	/	·	·	/	/	/	/	·	/	·	/	/	X	/	/	·	/	/	·	0	·	·	·	/	/	·	·	·	·	/	·	/	·	·	·	·	·	·	20
55	/	●	·	/	/	·	·	/	·	·	/	·	/	·	/	·	0	/	/	·	/	/	·	·	·	·	0	·	/	·	·	·	·	/	·	·	·	·	·	·	·	·	16
54	·	X	/	·	/	·	·	0	·	/	X	●	/	·	/	·	0	/	·	·	/	/	·	/	·	·	0	/	/	·	·	/	·	/	·	/	·	·	·	·	·	·	20
53	/	/	·	·	·	·	·	/	·	·	·	●	·	·	/	·	/	/	·	·	·	/	·	·	·	·	/	/	/	·	·	·	·	·	·	·	·	·	·	·	·	·	11
52	·	●	·	·	/	·	·	/	/	/	/	/	/	·	/	·	/	/	/	·	·	·	·	·	·	·	·	·	/	·	·	·	·	/	·	/	·	/	·	·	·	·	16
51	·	/	·	·	·	·	·	/	/	/	/	·	·	·	/	·	/	/	/	·	/	·	·	·	·	·	/	·	/	·	·	·	·	/	·	·	/	·	·	·	·	·	14
50	·	0	·	·	/	·	·	X	·	·	/	●	·	·	·	·	X	·	/	·	·	·	·	·	·	·	/	/	·	·	·	·	·	/	·	·	·	·	·	·	·	·	10
49	·	/	·	/	/	·	·	/	·	·	X	·	/	·	·	/	●	/	/	·	·	·	·	/	·	·	0	0	/	·	·	X	/	/	·	·	·	/	/	·	·	·	19
48	/	·	·	·	/	·	·	·	/	/	●	·	/	·	/	·	/	/	/	·	/	/	·	/	·	·	X	X	/	·	·	0	·	/	·	·	·	/	/	·	·	·	20
47	·	/	/	·	·	·	·	0	·	0	X	·	/	·	·	/	●	/	·	·	·	·	·	/	·	·	/	/	X	·	·	X	·	·	·	·	/	·	/	·	·	·	16
46	·	●	·	·	X	·	·	X	·	0	●	·	·	·	/	/	●	·	·	·	/	·	·	X	·	·	/	0	/	·	·	X	·	/	·	·	·	·	●	·	·	·	16
45	·	X	·	·	/	·	·	X	·	/	0	/	/	·	/	·	●	·	/	·	/	·	·	/	/	·	/	●	/	·	·	X	·	/	·	·	·	·	0	·	·	·	19
44	·	/	/	·	●	·	·	X	·	0	X	/	/	·	·	X	●	·	/	·	/	·	·	/	/	·	/	/	/	·	·	·	·	·	·	·	·	·	·	/	·	·	18
43	·	/	/	·	0	·	·	X	·	●	X	·	·	·	/	●	0	/	/	·	·	·	·	●	/	·	/	·	X	·	·	·	·	·	·	·	·	·	·	/	/	·	17
42	·	/	/	·	X	·	·	/	·	/	X	·	/	·	·	/	●	/	/	·	·	/	·	/	/	·	●	·	/	·	·	·	/	·	/	·	·	·	·	·	/	/	20
41	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	0
40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	0
39	/	X	·	·	●	·	·	0	·	0	·	/	/	·	·	/	●	/	·	·	/	/	·	X	·	·	/	·	·	·	·	·	·	·	·	·	·	·	·	·	·	/	15

Frequency Key

Symbol	Number of Specimens/ Horizontal Traverse of Slide (2x4 cm) @ 250X
●	>20
O	11–20
X	5–10
/	<5
Blank	0

PLATE 8
All Figures 800x

1. *Mesocena circulus* (Ehrenberg) Ehrenberg. #65.
2. *Mesocena* sp. cf. *M. circulus*. #43.
3. *Mesocena elliptica* (Ehrenberg) Ehrenberg. #69.
4. *Mesocena diodon* Ehrenberg s. ampl. #57.
5. *Mesocena hexagona* Haeckel. #68.
6. *Mesocena* sp. cf. *M. triangula*. #48.
7. *Mesocena triangula* Ehrenberg. #64.

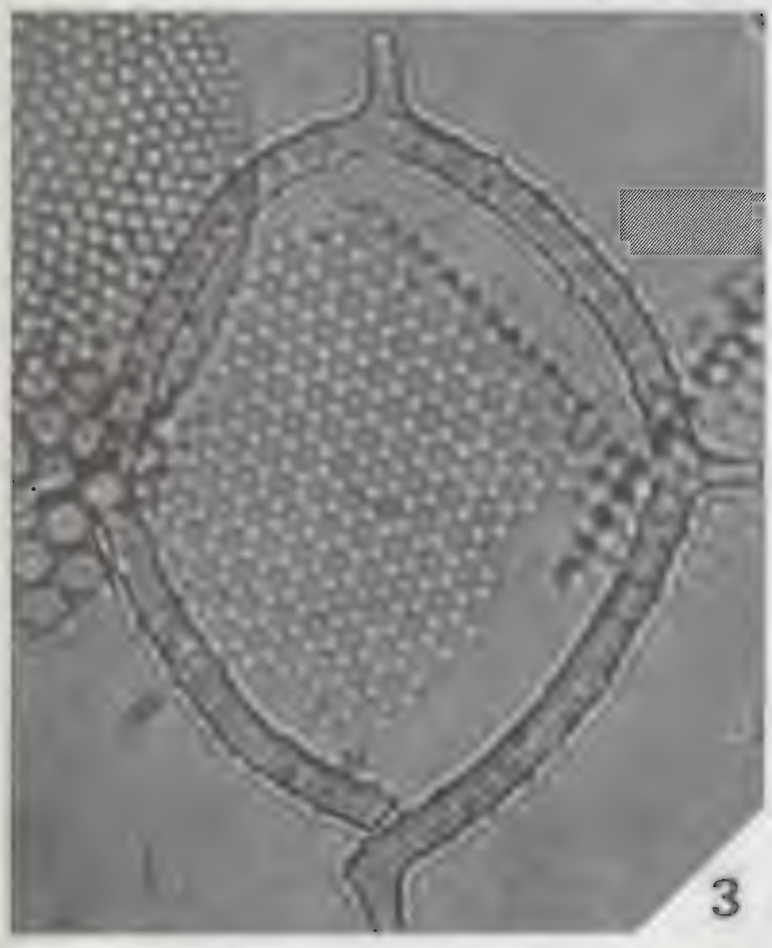
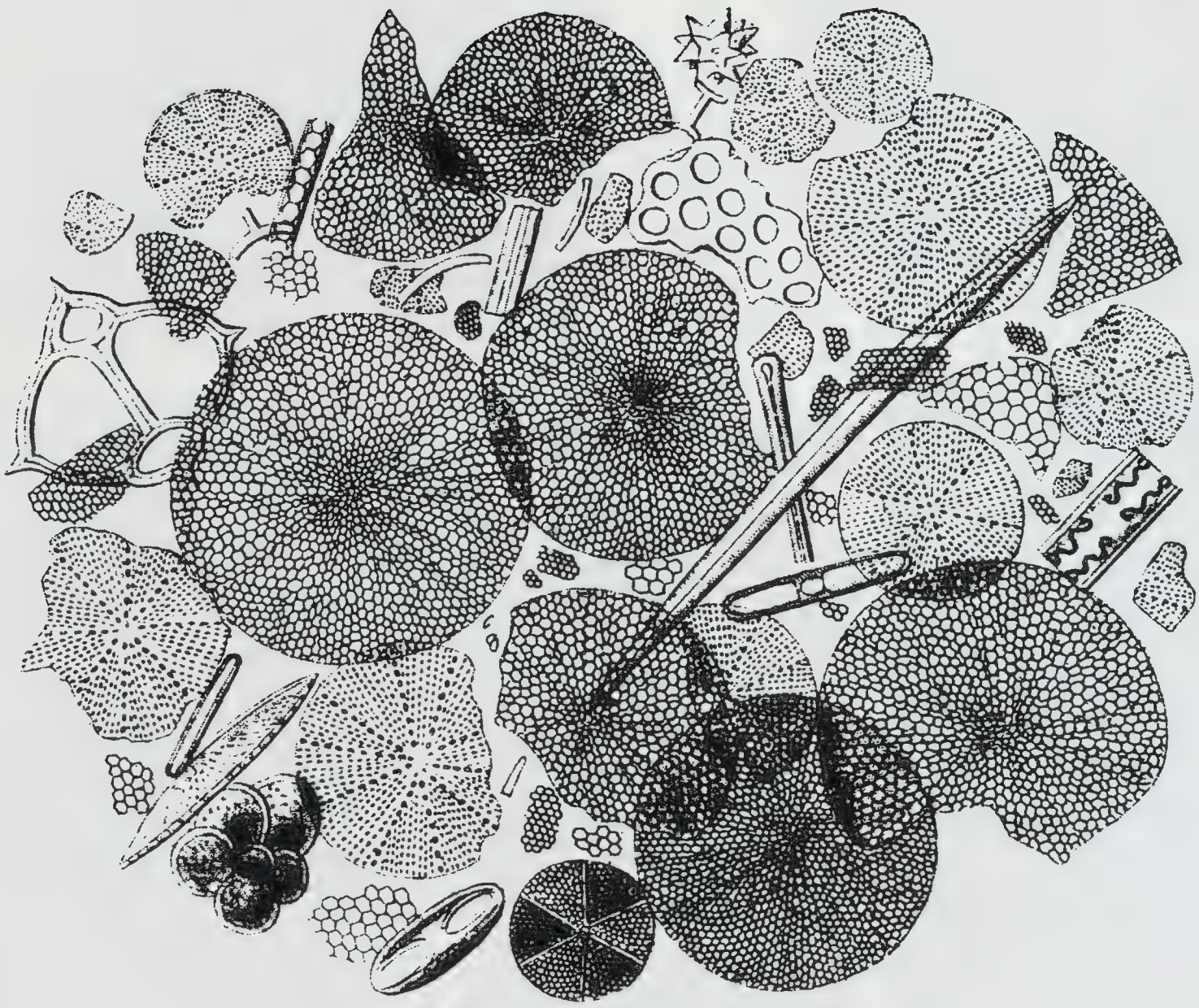


PLATE 8



BIBLIOGRAPHY

ANDREWS, G. W., 1975, Taxonomy and stratigraphic occurrence of the marine diatom genus *Rhaphoneis*: Proc. Nova Hedwigia, Third Symposium on Recent and Fossil Marine Diatoms, p. 193-219, 5 pls., 1 text-fig.

ARNOLD, R., and R. ANDERSON, 1907, Geology and oil resources of the Santa Maria oil district, Santa Barbara County, California: U. S. Geol. Survey, Bull. 322, 161 pp., 26 pls.

BACHMANN, A., and W. ICHIKAWA, 1962, The silicoflagellides in the Wakura Beds, Nanao City, Prefecture Ishikawa, Japan: Sci. Repts. Kanazawa Univ., v. 3, p. 161-175, 10 pls., 4 text-figs.

BAILEY, J. W., 1853 [1854], Notes on new species and localities of microscopical organisms: Smithsonian Contr. Knowl., v. 7, art. 3, 16 pp.

BAILEY, J. W., 1856, Notice of microscopic forms found in the surroundings of the Sea of Kamtschatka: Amer. Journ. Sci., v. 22 (ser. 2), p. 1-6, 1 pl.

BARRON, J. A., 1975, Late Miocene-Early Pliocene marine diatoms from southern California: Paleontographica, Abt. B., v. 151, p. 97-170.

BARRON, J. A., 1976, Revised Miocene and Pliocene diatom biostratigraphy of Upper Newport Bay, Newport Beach, California: Marine Micropalontology, v. 1, p. 27-63, 3 pls., 7 text-figs., 5 tbls.

BARRON, J. A., 1980, Lower Miocene to Quaternary diatom biostratigraphy of Leg 57, off northeastern Japan, Deep Sea Drilling Project: Init. Repts. DSDP, v. 56, 57, pt. 2, p. 641-685.

BARRON, J. A., 1981, Late Cenozoic diatom biostratigraphy and paleoceanography of the middle-latitude North Pacific, Deep Sea Drilling Project Leg 63: *in* R. S. YEATS, *et al.*, Init. Repts. DSDP, v. 63, p. 507-538.

BARRON, J. A., and G. KELLER, 1983, Paleotemperature oscillations in the Middle and Late Miocene of the northeastern Pacific: Micropaleontology, v. 29, p. 150-181, 3 pls., 12 text-figs., 9 tbls.

BARRON, J. A., and R. VON HUENE, 1978, Correlation of high and low latitude Upper Miocene diatom datum levels at DSDP site 438 in the northwest Pacific [abstract]: Correlation of tropical through high latitude marine deposits of the Pacific basin, International Geological Correlation Programme, project 114, third working group meeting, Stanford, Calif., p. 5-7.

BENSON, R. N., 1966, Recent Radiolaria from the Gulf of California: Minnesota Univ., unpublished Ph. D. dissertation, 577 pp., 12 text-figs., 2 tbls.

BJORKLUND, K., 1977, *Actinomma haysi*, n. sp., its Holocene distribution and size variation in Atlantic ocean sediments: Micropaleontology, v. 23, p. 114-126, 1 pl., 6 text-figs., 2 tbls.

BLUEFORD, J. R., 1983, Distribution of Quaternary Radiolaria in the Navarin Basin geologic province, Bering Sea: Deep-Sea Research, v. 30, no. 7A, p. 763-781, 12 text-figs., 1 tbl.

BORGERT, A. H. C., 1890, Über den Bau von *Distephanus (Dictyocha) speculum* Ehrbg. sp.: Zool. Anz., v. 13, p. 227-231.

BOYER, C. S., 1926-1927, Synopsis of North American Diatomaceae: Proc. Acad. Nat. Sci. Philadelphia, v. 78, supplement, part 1, p. 1-228; v. 79, supplement, part 2, p. 229-583.

BREBISSON, A., and R. GODEY, 1838, Considéations sur les Diatomées et essai d'une classification des genres et des espèces appartenant á cette famille: Falaise, 1838, p. 1-20.

BRIGHTWELL, T. F., 1853, On the genus *Triceratium*, with descriptions and figures of the species: Quart. Journ. Micr. Sci., v. 1, p. 245-252, pl. 4.

BRIGHTWELL, T. F., 1858, Further observations on the genera *Triceratium* and *Chaetoceros*: Quart. Journ. Micr. Sci., v. 6, p. 153-155, pl. 7.

BROWN, N. E., 1933, *Arachnoidiscus*: W. Watson and Sons, Ltd., London, 88 pp., 7 pls.

BRUN, J., 1894, Espèces nouvelles: Le Diatomiste, v. 2, pp. 72-78, 86-88, pls. 5, 6.

BRUN, J., 1896, Diatomées Miocènes: Le Diatomiste, v. 2, p. 229.

BUKRY, D., 1973, Coccolith and silicoflagellate stratigraphy, Deep Sea Drilling Project Leg 18, eastern North Pacific: *in* L. D. KULM, R. VON HUENE *et al.*, Init. Repts. DSDP, v. 18, p. 817-831, 3 pls., 5 text-figs.

BUKRY, D., 1975a, Phytoplankton stratigraphy, southwest Pacific, Deep Sea Drilling Project Leg 30: *in* J. E. ANDREWS, G. PACKHAM *et al.*, Init. Repts. DSDP, v. 30, p. 539-547, 1 pl., 5 text-figs.

BUKRY, D., 1975b, Coccolith and silicoflagellate stratigraphy, northwestern Pacific Ocean, Deep Sea Drilling Project Leg 32: *in* R. L. LARSON, R. MOBERLY *et al.*, Init. Repts. DSDP, v. 32, p. 677-701, 4 pls., 5 text-figs., 4 tbls.

BUKRY, D., 1976a, Silicoflagellate and coccolith stratigraphy, southwestern Pacific Ocean, Deep Sea Drilling Project Leg 34: *in* R. S. YEATS, S. R. HART *et al.*, Init. Repts., DSDP, v. 34, p. 715-735, 4 pls., 8 text-figs.

BUKRY, D., 1976b, Cenozoic silicoflagellate and coccolith stratigraphy, South Atlantic Ocean, Deep Sea Drilling Project Leg 36: *in* C. D. HOLLISTER, C. CRADDOCK *et al.*, Init. Repts. DSDP, v. 35, p. 885-917, 9 pls., 2 text-figs., 5 tbls.

BUKRY, D., 1976c, Silicoflagellate and coccolith

stratigraphy of the Norwegian-Greenland Sea, Deep Sea Drilling Project Leg 38: *in* M. TALWANI, G. UDINTSEV *et al.*, Init. Repts. DSDP, v. 38, p. 843-855, 2 pls., 4 tbls.

BUKRY, D., 1978a, Cenozoic coccolith and silicoflagellate stratigraphy, offshore northwest Africa, Deep Sea Drilling Project Leg 41: *in* Y. LANCELOT, E. SEIBOLD *et al.*, Init. Repts. DSDP, v. 41, p. 689-707, 3 pls., 6 text-figs.

BUKRY, D., 1978b, Cenozoic coccolith, silicoflagellate, and diatom stratigraphy, Deep Sea Drilling Project Leg 44: *in* W. E. BENSON, R. E. SHERIDAN *et al.*, Init. Repts. DSDP, v. 44, p. 807-863, 19 pls. 6 text-figs.

BUKRY, D., 1979a, Comments on opal phytoliths and stratigraphy of Neogene silicoflagellates and coccoliths at Deep Sea Drilling Project Site 397 off northwest Africa: *in* B. P. LUYENDYK, J. R. CANN *et al.*, Init. Repts. DSDP, v. 49, p. 977-1009, 10 pls., 5 text-figs.

BUKRY, D., 1979b, Coccolith and silicoflagellate stratigraphy, northern Mid-Atlantic Ridge and Reykjanes Ridge, Deep Sea Drilling Project Leg 49: *in* B. P. LUYENDYK, J. R. CANN *et al.*, Init. Repts. DSDP, v. 49, p. 551-581, 8 pls., 8 text-figs.

BUKRY, D., 1980, Miocene *Corbisema triacantha* Zone phytoplankton from Deep Sea Drilling Project Sites 415 and 416, off northwest Africa: *in* Y. LANCELOT, E. L. WINTERER *et al.*, Init. Repts. DSDP, v. 50, p. 507-523, 6 pls., 3 text-figs.

BUKRY, D., 1981, Silicoflagellate stratigraphy of offshore California and Baja California, Deep Sea Drilling Project Leg 63: *in* R. S. YEATS, B. U. HAQ *et al.*, Init. Repts. DSDP, v. 63, p. 539-557, 5 pls., 9 text-figs.

BUKRY, D., 1982a, Cenozoic silicoflagellates from offshore Guatemala, Deep Sea Drilling Project Site 495: *in* R. VON HUENE, J. AUBOIN *et al.*, Init. Repts. DSDP, v. 67, p. 425-445, 9 pls., 3 text-figs.

BUKRY, D., 1982b, Neogene silicoflagellates of the eastern equatorial Pacific, Deep Sea Drilling Project Hole 503A: *in* W. L. PRELL, J. V. GARDNER *et al.*, Init. Repts. DSDP, v. 68, p. 311-323, 6 pls., 2 text-figs.

BUKRY, D., 1983, Upper Cenozoic silicoflagellates from offshore Ecuador, Deep Sea Drilling Project Site 504: *in* J. R. CANN, M. G. LANGSETH *et al.*, Init. Repts. DSDP, v. 69, p. 321-342, 9 pls., 3 text-figs.

BUKRY, D., and J. H. FOSTER, 1973, Silicoflagellate and diatom stratigraphy, Leg 16, Deep Sea Drilling Project: *in* T. H. VAN ANDEL, G. R. HEATH *et al.*, Init. Repts. DSDP, v. 16, p. 815-871, 17 pls., 1 text-fig., 12 tbls.

BURCKLE, L. H., 1969, Late Cenozoic planktonic diatom zones in equatorial Pacific sediments [abstract]: Geol. Soc. America, Abs. for 1969, pt. 7, p. 24.

BURCKLE, L. H., 1971, Correlation of Late Cenozoic marine sections in Japan and the Equatorial Pacific: Trans. Proc. Palaeont. Soc. Japan, (N.S.), v. 82, p. 117.

BURCKLE, L. H., 1972, Late Cenozoic planktonic diatom zones from the eastern equatorial Pacific, *in* R. SIMONSEN (ed.), First Symposium on Recent and Fossil Marine Diatoms: Nova Hedwigia, v. 39, p. 217-246, pls. 1-3, figs. 1-4.

CAMPBELL, A. S., 1951, New genera and subgenera of Radiolaria: Journ. Paleontology, v. 25, p. 527-530.

CAMPBELL, A. S., and B. L. CLARK, 1944, Miocene radiolarian faunas from southern California: Geol. Soc. America, Spec. Paper 51, ivii + 76 pp., 7 pls., 2 tbls.

CASEY, R. E., 1971, Radiolarians as indicators of past and present water masses, *in* B. M. FUNNELL and W. R. RIEDEL (eds.), Micropaleontology of Oceans, Cambridge Univ. Press, Cambridge, 331 pp.

CASEY, R. E., A. B. PRICE, and C. A. SWIFT, 1972, Radiolarian definition and paleoecology of the Late Miocene to Early Pliocene in Southern California, *in* E. H. STINEMEYER (ed.), Pacific Coast Miocene Biostratigraphic Symposium: Soc. Econ. Paleont. Mineral., Pacific Sect., 47th Proc., p. 226-228, 3 pls., 5 figs.

CASTRANE, C., 1886, Report on the scientific results of the voyage of H.M.S. *Challenger* during the years 1873-1876, Botany, v. 2, 178 pp., 30 pls.

CLARK, B. L., and A. S. CAMPBELL, 1942, Eocene radiolarian faunas from the Mt. Diablo area, California: Geol. Soc. America, Spec. Paper 39, 112 pp., 9 pls., 5 text-figs.

CLEVE, P. T., 1873, On diatoms from the Arctic Sea: Handl. Kgl. Svensk. Vetenskapsakad., v. 13, p. 1.

CLEVE, P. T., 1883, Diatoms collected during the expedition of the "Vega": Vega-Exped. Vetenskap. Iakttagelser, v. 3, p. 457-517.

CLEVE, P. T., 1894-1895, Synopsis of the naviculoid diatoms: Handl. Kgl. Svensk. Vetenskapsakad., [part 1] v. 26, p. 1-194, pls. 1-5; [part 2] v. 27, p. 1-220, pls. 1-4.

CLEVE-EULER, A., 1944, Die Diatomeen als quartär-geologische Indikatoren, eine kritische Übersicht: Geologisk föreningen Förhandlingar, v. 66, Stockholm.

CUPP, E. A., 1943, Marine plankton diatoms of the west coast of North America: Bull. Scripps Inst. Ocean., v. 5, p. 1-238, pls. 1-5, 168 figs.

DEFLANDRE, G., 1932, Sur la systématique des Silicoflagellés: Bull. Soc. Bot. France, v. 79, p. 494-506, figs. 1-42.

DEFLANDRE, G., 1950, Contribution a l'études des silicoflagellidés actuels et fossiles (suite et

fin): Microscopie, v. 2, p. 191-210, figs. 174-243.

DOGIEL, V. A., and V. V. RESHETNYAK, 1952, Materialy po radiolyariyam severozapadnoi chasti tikhogo okeana: Issledovanya Dalnevostochnykh Morei SSSR, no. 3, p. 5-36.

DONAHUE, J. G., 1970, Pleistocene diatoms as climate indicators in North Pacific sediments: Geol. Soc. America, Mem. 126, p. 121-138, pls. 1-3, figs. 1-6.

DREYER, F., 1889, Morphologische Radiolarienstudien, 1. Die Pylombildungen in vergleichend-anatomischer und entwicklungsgeschichtlicher Beziehung bei Radiolarien und bei Protisten überhaupt, nebst System und Beschreibung neuer und des bis jetzt bekannten pylomatishen Spumellarien: Jenaische Zeitschr. Naturw., v. 23, (n.ser., v. 16), p. 235-432, pls. 6-11.

DUMITRICA, P., 1973a, Miocene and Quaternary silicoflagellates in sediments from the Mediterranean Sea: *in* W. B. F. RYAN, K. J. HSÜ *et al.*, Init. Repts. DSDP, v. 13, p. 902-933, 12 pls., 4 text-figs.

DUMITRICA, P., 1973b, Paleocene, Late Oligocene and post-Oligocene silicoflagellates in southwestern Pacific sediments cored on DSDP Leg 21: *in* R. E. BURNS, J. E. ANDREWS *et al.*, Init. Repts. DSDP, v. 21, p. 837-883, 13 pls., 6 text-figs.

DUMITRICA, P., 1973c, Phaeodarian radiolaria in southwest Pacific sediments cored during Leg 21 of the Deep Sea Drilling Project: *in* R. E. BURNS, J. E. ANDREWS *et al.*, Init. Repts. DSDP, v. 21, p. 751-785, 13 pls.

DUMITRICA, P., 1978, Badenian radiolaria from Central Paratethys: Stratigraphic Correlation Tethys-Paratethys Neogene of the International Correlation Programme, p. 231-261, 7 pls., text-figs. 53, 54.

DUMONT, M. P., 1984, Miocene/Pliocene epoch boundary determined from diatom biostratigraphy in the Lompoc, California region: Geol. Soc. America, 9th Annual Meeting, Abstracts with Programs, v. 16, no. 6, p. 496.

EHRENBERG, C. G., 1830 [1832], Beiträge zur Kenntniss der Organisation der Infusorien und iher geographischen Verbreitung, besonders in Sibirien: Abh. Kgl. Akad. Wiss. Berlin, p. 1-88, 8 pls.

EHRENBERG, C. G., 1831 [1832], Über die Entwicklung und Lebensdauer der Infusionsthiere, nebst ferneren Beiträgen zu einer Vergleichung ihrer organischen Systeme: Abh. Kgl. Akad. Wiss. Berlin, p. 1-154, 4 pls.

EHRENBERG, C. G., 1832, Zur Erkenntniss der Organisation in der Richtung des kleinsten Raumes. Zweiter Beitrag. Entwickelung, Lebensdauer und Struktur der Magenthiere und Räderthiere oder sogenannten Infusorien; nebst einer physiologischen Characteristik beider Klassen und 412 Arten derselben: Abh. Kgl. Akad. Wiss. Berlin, col. pl.

EHRENBERG, C. G., 1833, Dritter Beiträge zur Erkenntniss grosser Organisation in der Richtung des kleinsten Raumes: Abh. Kgl. Akad. Wiss. Berlin, p. 145-336, pls. 1-11.

EHRENBERG, C. G., 1835 [1837], Zusätze zur Erkenntniss grosser organischer Ausbildung in den kleinsten theirischen Organismen: Abh. Kgl. Akad. Wiss. Berlin, p. 151-180.

EHRENBERG, C. G., 1836 [1838], Über das Massenverhältniss der jetzt lebenden Kiesel-Infusorien und über ein neues Infusorien-Conglomerat als Polirschiefer von Jastraba in Ungarn: Abh. Kgl. Akad. Wiss. Berlin, p. 109-135, pls. 1, 2. (This paper appears in the proper order of paging in the Ablhandlungen for 1836. Below the title of the paper is a note that it was read July 20 and August 3, 1837, and printed in December.)

EHRENBERG, C. G., 1837a, Eine briefliche Nachricht des Hrn. Agassiz in Neuchatel über den ebenfalls aus mikroscopischen Kiesel-Organismen gebildeten Polirschiefer von Oran in Africa: Verh. Kgl. Akad. Wiss. Berlin, p. 59-61.

EHRENBERG, C. G., 1837b, Die fossilen Infusorien und die lebendige Dammerde: Abh. Kgl. Akad. Wiss. Berlin, 1 pl., 2 text-figs.

EHRENBERG, C. G., 1838, Die Infusionsthierchen als vollkommende Organismen, ein Blick in das tiefere organische Leben de Natur: Leopold Voss, Leipzig, xvii + 548 pp., 64 pls.

EHRENBERG, C. G., 1839, Über die Bildung der Kreidefelsen und des Kreidemorgels durch unsichtbare Organismen: Abh. Kgl. Akad. Wiss. Berlin, p. 59-147, 4 pls., 2 tbls.

EHRENBERG, C. G., 1840a, Über ausgezeichnete jetzt lebende peruanische und mexikanische Meeres-Infusorien, welche mit zur erläuterung räthselhafter fossiler Formen der Kreidebildung dienen: Ber. Kgl. Akad. Wiss. Berlin, p. 157-162.

EHRENBERG, C. G., 1840b, Über noch jetzt zahlreich lebende Thierarten der Kreidebildung und den Organismus der Polythalamien: Abh. Kgl. Akad. Wiss. Berlin, p. 88-174, 4 pls.

EHRENBERG, C. G., 1840c, 274 Blätter von ihmm selbst ausgeführter Zeichnungen von ebenso viele Arten: Verh. Kgl. Akad. Wiss. Berlin, p. 197-219.

EHRENBERG, C. G., 1841 [1843], Verbreitung und Einfluss des mikroskopischen Lebens in Süd- und Nord-Amerika: Abh. Kgl. Akad. Wiss. Berlin, p. 291-445, 4 pls.

EHRENBERG, C. G., 1842, Über eine plastischen Kreidemergel von Aegina: Ber. Kgl. Akad. Wiss. Berlin, p. 263.

EHRENBERG, C. G., 1843a, Über die weitere Entwickelung der Verbreitung und Einflus-

ses des mikroskopischen Lebens in Afrika: Ber. Kgl. Akad. Wiss. Berlin, p. 133-137.

EHRENBERG, C. G., 1843b, Über den Gehalt an unsichtbar kleinen Lebensformen aus einigen von Prof. Koch aus Constantinopel eingesandten Proben der Meeresablagerungen in Marmara Meer und im Bosphorus: Ber. Kgl. Akad. Wiss. Berlin, p. 253.

EHRENBERG, C. G., 1844a, Über das kleinste Leben im Weltmeer am Südpol und in die Meerestiefen. Berlin.

EHRENBERG, C. G., 1844b, Über zwei neue Lager von Gebirgsmassen aus Infusoria; als Meeres-Absatz in Nord-Amerika und eine Vergleichung derselben mit den organischen Kreide-Gebilden in Europa und Afrika: Abh. Kgl. Akad. Wiss. Berlin, p. 57-97. *Notice by* J. W. Bailey "Ehrenberg's Observations on the fossil Infusoria of Virginia and Maryland and comparisons of the same with those found in the chalk formations of Europe and America, Amer. Journ. Sci., v. 48, p. 201-204 [1844].

EHRENBERG, C. G., 1844c, Einige vorläuflige Resultate seiner Untersuchungen der ihm von der Südpolreise des Capitain Ross, so wie von den Herren Schayer und Darwin zugekommenen Materialien über das Verhalten des kleinsten Lebens in den Oceanen und den grössten bisher zugänglichen Tiefen des Weltmeers: Ber. Kgl. Akad. Wiss. Berlin, p. 182-207.

EHRENBERG, C. G., 1845, Neue Untersuchungen über das kleinste Leben als Geolgisches Moment, Mit kurzer Charakteristik von 10 neuen Genera und 66 neuen Arten: Ber. Kgl. Akad. Wiss. Berlin, p. 53-88.

EHRENBERG, C. G., 1847a, Mittheilung über vor kurzem vom der Preuss. Seehandlungsschiffe der "Adler", aus Canton mitgebrachte, verkäufliche, chinesische Blumenculturerde, über deren reiche Mischung mit mikroskopischen Organismen und Verzeichniss von 124 von ihm selbst beobachteten Arten chinesischer kleinster Lebensformen: Ber. Kgl. Akad. Wiss. Berlin, p. 476-487.

EHRENBERG, C. G., 1847b, Über die mikroskopischen kieselschaligen Polycystinen als machtige Gebirgsmasse von Barbados: Ber. Kgl. Akad. Wiss. Berlin, p. 40-60.

EHRENBERG, C. G., 1849, Monatsber. Kgl. Akad. Wiss. Berlin, p. 64.

EHRENBERG, C. G., 1853, Weisser Biolitischer Süsswasser-Mergel vom See Garag in Fajum. Berlin.

EHRENBERG, C. G., 1854a, Mikrogeologie. Das Erden und Felsen Schaffende Wirken des unsichtbar kleinen selbständigen Lebens auf der Erde: Leopold Voss, Leipzig, Text, xxviii + 374 pp.; Atlas, 31 pp., 41 pls.

EHRENBERG, C. G., 1854b, Die systematische Characteristik der neuen mikroscopischen Organismen des tiefen atlantischen Oceans: Ber. Kgl. Akad. Wiss. Berlin, p. 236-250.

EHRENBERG, C. G., 1856, Über das mikroskopische leben der centralen landflächen mittel-Afrika's, nach Dr. Vogel's materialien: Monatsber. Kgl. Akad. Wiss. Berlin, p. 323-339, 1 pl.

EHRENBERG, C. G., 1858, Kurze Charakteristik der 9 neuen Genera und 105 neuen Species des ägaischen Meeres und des Tiefgrundes des Mittelmeeres: Monatsber. Kgl. Akad. Wiss. Berlin, p. 10-66.

EHRENBERG, C. G., 1860, Über den Tiefgrund des stillen Oceans zwischen Californien und d. Sandwich Inseln aus 15,600 Fuss Tiefe: Monatsber. Kgl. Akad. Wiss. Berlin, p. 819-850.

EHRENBERG, C. G., 1861, Über die Tiefgrunde Verhältnisse des Oceans am Eingange der Davisstrasse und bei Island, Nebst einem Übersichts Kärtschen: Monatsber. Kgl. Akad. Wiss. Berlin, p. 275-315.

EHRENBERG, C. G., 1862, Über die seit 27 Jahren noch wohl erhaltenen Organisations-Präparate des mikroskopischen Lebens: Abh. Kgl. Akad. Wiss. Berlin.

EHRENBERG, C. G., 1872, Mikrogeologische Studien als Zusammenfassung seiner Beobachtungen des kleinsten Lebens der Meeres-Tiefgrunde aller Zonen und dessen geologischen Einfluss: Monatsber. Kgl. Akad. Wiss. Berlin, p. 265-322.

EHRENBERG, C. G., 1872 [1873], Mikrogeologische Studien über das kleinst Leben der Meerestiefgründe aller Zonen und Desseu geologischen Einfluss: Abh. Kgl. Akad. Wiss. Berlin, p. 131-397, pls. 1-12.

EHRENBERG, C. G., 1873, Grössere Felsproben des Polycysten-Mergel von Barbados mit weiteren Erlauterungen: Monatsber. Kgl. Akad. Wiss. Berlin, p. 312-363.

EHRENBERG, C. G., 1875 [1876], Forsetzung der mikrogeologischen Studien als Gesammt Übersicht der mikroskopischen Paläontologie gleichartig analysirter Gebirgsarten der Erde mit specieller Rüchsicht auf den Polycystinen-Mergel von Barbados: Abh. Kgl. Akad. Wiss. Berlin, p. 1-225, 30 pls.

FOREMAN, H. P., 1973, Radiolaria of Leg X with systematics and ranges for the families Amphipyndacidae, Artostobiidae and Theoperidae: *in* J. W. WORZEL, W. BRYANT *et al.*, Init. Repts. DSDP, v. 10, p. 407-474, 13 pls., 7 text-figs., 7 tbls.

FRENGUELLI, J., 1949, Diatomeas fósiles de los yacimientos chilenos de Tiltil y Mejillones: Darwinia, v. 2, no. 1, p. 97.

GLEZER, Z. I., 1966, Silicoflagellatophyceae, *in* M. M. GOLLERBAKH (ed.), Cryptogamic plants of the U.S.S.R.: Akad. Nauk, SSSR, V. A. Kamarova Bot. Inst. (Translated from Russian by Israel Program for Scientific Translations Ltd., Jerusalem, 1970), v. 7, p. 1-

363, 33 pls., 28 text-figs.

GOLL, R. M., 1968, Classification and phylogeny of Cenozoic Trissocyclidae (Radiolaria) in the Pacific and Caribbean Basins, part I: Journ. Paleontology, v. 42, p. 1409-1432.

GRAN, H. H., and E. C. ANGST, 1931, Plankton diatoms of Puget Sound: Publ. Puget Sound Biol. Sta. Unit, Washington, v. 7, p. 417.

GRAN, H. H., 1897, Bacillariaceen vom Kleinen Kdarajakfjord: Bibl. Bot., v. 42, p. 13-24.

GREGORY, W., 1855, On some new species of British fresh water Diatomaceae, with remarks on the value of certain specific characters: Proc. Botanical Soc. Edinburgh, 1855, p. 38-76.

GREGORY, W., 1857, On new forms of marine Diatomaceae found in the Firth of Clyde and in Loch Fyne: Trans. Roy. Soc. Edinburgh, v. 4, no. 21, p. 473.

GREYVILLE, R. K., 1860, A monograph of the genus *Asterolampra* including *Asteromphalus* and *Spatangium*: Trans. Micr. Soc. London, v. 8, p. 102-124.

GREYVILLE, R. K., 1861, Descriptions of new and rare diatoms: Trans. Micr. Soc. London, [n.ser.], v. 9, ser. I, p. 39-45; ser. II, p. 67-73; ser. III, p. 73-79; ser. IV, p. 79-87; pls. 4, 8, 9, 10.

GREYVILLE, R. K., 1862, Descriptions of new and rare diatoms: Trans. Micr. Soc. London, [n.ser.], v. 10, ser. V, p. 18-29, pls. 2, 3; ser. VI, p. 89-96, pl. 9.

GRUNOW, A., 1867, Diatomeen auf *Sargassum* von Honduras, gesammelt von Lindig: Hedwigia, v. 6, no. 1-3, p. 1-8, 17-37.

GRUNOW, A., 1878, *in* SCHNEIDER, Naturw. Beitr. 2, Kenntn. der Kaukasuslander.

GRUNOW, A., 1880a, *in* P. T. CLEVE and A. GRUNOW, Beiträge zur Kenntniss der Artischen Diatomeen: Handl. Kgl. Svensk. Vetenskapsakad., v. 17, p. 3.

GRUNOW, A., 1880b, *in* H. VAN HEURCK, Synopsis des Diatomées de Belgique, Atlas: Ducaju et Cie., Anvers, pl. 1-30.

GRUNOW, A., 1881, *in* H. VAN HEURCK, Synopsis des Diatomées de Belgique, Atlas: Ducaju et Cie., Anvers, pl. 124, fig. 10.

GRUNOW, A., 1883, *in* H. VAN HEURCK, Synopsis des Diatomées de Belgique, Atlas: Ducaju et Cie., Anvers, p. 104-132,

GRUNOW, A., 1884, Die Diatomeen von Franz Josefs-Land: Dnkschr. Kgl. Akad. Wiss. Wien, Math. Wiss. Kl., v. 48, p. 53-112, pls. 1-4.

HAECKEL, E., 1860, Fernere Abbildungen und Diagnosen neuer Gattungen und Arten von lebenden Radiolarien des Mittelmeeres: Monatsber. Kgl. Akad. Wiss. Berlin, p. 835-845.

HAECKEL, E., 1862, Die Radiolarien (Rhizopoda Radiaria), eine Monographie: Reimer, Berlin, xiv + 572 pp., 35 pls.

HAECKEL, E., 1879, Über die Phaeodarien, eine neue Gruppe kieselschaliger mariner Rhizopoden: Sitzungsb. Med.-Nat. Gesellsch. Jena.

HAECKEL, E., 1881, Entwurf eines Radiolarien-System auf Grund von Studien der Challenger-Radiolarien: Jenaische Zeitschr. Naturw., v. 15 (n.ser., v. 8; 1882), no. 3, p. 418-472.

HAECKEL, E., 1887, Report on the Radiolaria collected by H.M.S. *Challenger* during the years 1873-1876: Rept. Sci. Results Voyage of H.M.S. *Challenger* during the years 1873-1876, v. 18, i-cxxxvii + 1893 pp., 140 pls.

HANNA, G. D., 1927a, Cretaceous Diatoms from California: California Acad. Sci., Occasional Paper 13, 48 pp., 5 pls.

HANNA, G. D., 1927b, The lowest known Tertiary diatoms in California: Journ. Paleontology, v. 1, p. 103-126, pls. 17-21.

HANNA, G. D., 1930, Review of the genus *Rouxia*: Journ. Paleontology, v. 4, p. 179-188, pl. 14.

HANNA, G. D., 1932a, The diatoms of Sharktooth Hill, Kern County, California: California Acad. Sci., Proc. (n.ser.), v. 20, no. 6, p. 161-263, 17 pls.

HANNA, G. D., 1932b, Pliocene diatoms of Wallace County, Kansas: Univ. Kansas Science Bulletin, v. 20, no. 21, p. 369-394, pls. 31-34.

HANNA, G. D., 1970, Fossil diatoms from the Pribilof Islands, Bering Sea, Alaska: California Acad. Sci., Proc. (ser. 4), v. 37, no. 5, p. 167-234, figs. 1-105.

HANNA, G. D., and A. L. BRIGGER, 1964, Some fossil diatoms from Barbados: California Acad. Sci., Occasional Paper 45, 27 pp., 5 pls.

HANNA, G. D., and W. M. GRANT, 1926, Miocene marine diatoms from Maria Madre Island, Mexico, *in* 1925, II Expedition to the Revillagigedo Islands, Mexico: California Acad. Sci., Proc. (ser. 4), v. 15, no. 2, p. 115-193, pls. 11-21.

HARTING, P., 1863, Bijdrage tot de kennis der mikroskopische fauna en flora van de Banda-Zee: Verh. Kon. Akad. Wetensch. Amsterdam, v. 10, p. 1-34, 3 pls.

HAYS, J. D., 1965, Radiolaria and Late Tertiary and Quaternary history of Antarctic Seas, *in* Biology of the Antarctic Seas II: Amer. Geophys. Union, Antarctic Res. Ser., v. 5, p. 125-183, 3 pls., 38 text-figs., 4 tbls.

HAYS, J. D., 1970, Stratigraphy and evolutionary trends of Radiolaria in North Pacific deep-sea sediments, *in* J. D. HAYS (ed.), Geological Investigations of the North Pacific: Geol. Soc. America, Mem. 126, p. 185-218, 1 pl., 10 text-figs., 2 tbls.

HEINRICHS, D. F., 1973, Paleomagnetic studies of sediments from DSDP Site 173: *in* L. D. KULM, R. VON HUENE *et al.*, Init. Repts.

DSDP, v. 18, p. 843-846, 2 figs., 1 tbl.

HENDEY, N. I., 1937, The plankton diatoms of the southern seas: Discovery Repts., v. 16, p. 153-364, pls. 6-13.

HENDEY, N. I., 1964, An introductory account of the smaller algae of British coastal waters, Part 5, Bacillariophyceae (Diatoms): Fishery Invest., London, (ser 4), p. 1-317, pls. 1-45, text-figs. 1-9.

HUSTEDT, F., 1927-1932, Die Kieselalgen Deutschlands, Österreichs und der Schweiz mit Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete: *in* L. RABENHORST, Kryptogamen-Flora von Deutschland, Österreich und der Schweiz, v. 7, Part 1, Sect. 1-5, p. 1-920 (1927-1930); Part 2, Sect. 1-5, p. 1-736 (1931-1937). Akademische Verlagsgesellschaft Geest und Portig K. G., Leipzig.

HUSTEDT, F., 1930, Bacillariophyta (Diatomaceae): *in* A. PASCHER, Die Süsswasser-Flora Mitteleuropas, no. 10: Gustav Fischer, Jena, 2nd ed., 466 pp., 875 figs.

ICHIKAWA, W., I. SHIMIZU, and A. BACHMANN, 1967, Fossil silicoflagellates and their associated uncertain forms in Iida Diatomite, Noto Peninsula, Central Japan: Sci. Repts. Kanazawa Univ., v. 12, p. 143-172, 9 pls., 3 text-figs.

INGLE, J. C., JR., 1967, Foraminiferal biofacies variation and the Miocene-Pliocene boundary in southern California: Bull. Amer. Paleontology, v. 52, no. 236, p. 209-394, pls. 33-43, 43 text-figs., 14 tbls.

INGLE, J. C., JR., 1972, Biostratigraphy and paleoecology of Early Miocene through Early Pleistocene benthonic and planktonic foraminifera, San Joaquin Hills-Newport Bay, Orange County, California, *in* E. H. STINEMEYER (ed.), Pacific Coast Miocene Biostratigraphic Symposium: Soc. Econ. Paleont. Mineral., Pacific Sect., 47th Proc., p. 255-283.

ISAACS, C. M., 1981, Field characterization of rocks in the Monterey Formation along the coast near Santa Barbara, California, *in* C. M. ISAACS *et al.* (eds.), Guide to the Monterrey Formation in the California coastal area, Ventura to San Luis Obispo: Amer. Assoc. Petrol. Geol., Pacific Sect., v. 52, p. 39-54.

JANISCH, A. S., 1878, *in* A. SCHMIDT, Atlas der Diatomaceenkunde, pl. 57.

JØRGENSEN, E., 1900, Protophyten und Protozoen im Plankton aus der norwegischen Westküste: Bergen Mus. Arabog, 1899, no. 2 (no. 6), p. 1-112. 5 pls., 83 tbls.

JØRGENSEN, E., 1905a, The protist plankton and the diatoms in bottom samples: Bergen Mus. Skrift, ser. 1, no. 7, p. 49-151, 195-225, pls. 6-18.

JØRGENSEN, E., 1905b, The protist plankton and the diatoms in bottom samples: *in* O. NORDGAARD, Hydrographical and Biological Investigations in Norwegian Fjords: Bergen Mus. Skrift, John Grieg, Bergen, 254 pp.

JOUSÉ, A. P., 1959, Principal development stages of marine diatoms of the far east in the Tertiary and Quaternary periods: Botanicheskiy Zhurnal [Botanical Journal], v. 44, p. 44.

JOUSÉ, A. P., 1961, Diatoms and their roles in indicating the history of oceans: Izd. Akad. Nauk SSSR, Ser. Geog., v. 2, p. 13.

JOUSÉ, A. P., V. V. MUCHINA and O. G. KOZLOVA, 1969, Diatome i silikoflagellaty sloe osadkov Tikhogo Okeana [in Russian], *in* V. G. KORT (ed.), Tikhii Okean: Mikroflora i mikrofauna v sovremennykh osadkakh Tikhogo Okeana, Nauka, Moscow, p. 7-49, figs. 1-19.

JOUSÉ, A. P., G. KH. KAZARINA, and V. V. MUCHINA, 1982, Distribution of diatoms in Pliocene and Pleistocene deposits from the middle America trench off Guatemala: *in* R. VON HUENE, J. AUBOIN *et al.*, Init. Repts. DSDP, v. 67, p. 455-471, pls. 1-5, text-figs. 1-4, 4 tbls.

KANAYA, T., 1959, Miocene diatom assemblages from the Onnagawa Formation and their distribution in the correlative formations in northeast Japan: Sci. Repts. Tohoku Univ., 2nd ser. (Geol.), v. 30, p. 1-130, 11 pls., 7 charts, 1 text-fig.

KANAYA, T., and I. KOIZUMI, 1966, Interpretation of diatom thanatocoenoses from the North Pacific applied to a study of Core V20-130, (Studies of a deep-sea Core V20-130, Part IV): Sci. Repts. Tohoku Univ., 2nd ser. (Geol.), v. 37, p. 89.

KANAYA, T., and I. KOIZUMI, 1970, The progress in the younger Cenozoic diatom biostratigraphy in the Northern Circum-Pacific region: Journ. Marine Geology (Japan), v. 6, p. 47.

KELLER, G., and J. A. BARRON, 1981, Integrated planktic foraminiferal and diatom biochronology for the northeast Pacific and the Monterey Formation, *in* The Monterey Formation and Related Siliceous Rocks of California: Soc. Econ. Paleont. Mineral., Pacific Sect., Proc., p. 43-54, 6 text-figs.

KELLER, G., and J. A. BARRON, 1983, Paleoceanographic implications of Miocene deep-sea hiatuses: Geol. Soc. America, Bull., v. 94, p. 590-613, 15 text-figs., 2 tbls.

KELLER, G., J. A. BARRON, and L. H. BURCKLE, 1982, North Pacific Late Miocene correlations using microfossils, stable isotopes, percent $CaCO_3$, and magnetostratigraphy: Marine Micropaleontology, v. 7, p. 327-357, 10 text-figs.

KLING, S. A., 1973, Radiolaria from the eastern North Pacific Deep Sea Drilling Project, Leg

18: *in* L. D. KULM, R. VON HUENE *et al.*, Init. Repts. DSDP, v. 18, p. 155-182, 17 text-figs., 12 tbls.

KOIZUMI, I., 1968, Tertiary diatom flora of Oga Peninsula, Akita Prefecture, Northeast Japan: Sci. Repts. Tohuku Univ., 2nd ser. (Geol.), v. 40, p. 171.

KOIZUMI, I., 1972, Marine diatom flora of the Pliocene Tatsunokuchi Formation in Fukushima Prefecture, Northeast Japan, (n.s.), v. 86, p. 340.

KOIZUMI, I., 1973a, The Late Cenozoic diatoms of sites 183-193, Leg 19, Deep Sea Drilling Project: *in* P. R. SUPKO, Init. Repts. DSDP, v. 19, p. 805-855, pl. 1-8, figs. 1-13.

KOIZUMI, I., 1973b, Marine diatom flora of the Pliocene Tatsunokuchi Formation in Miyagi Prefecture: Trans. Proc. Palaeont. Soc. Japan, (n.s.), v. 79, p. 126-136, pl. 20.

KOIZUMI, I., 1975, Neogene diatoms from the western margin of the Pacific Ocean, Leg 31, Deep Sea Drilling Project: *in* D. E. KARIG, J. C. INGLE, JR., *et al.*, Init. Repts. DSDP, v. 31, p. 779-819.

KOLBE, R. W., 1954, Diatoms from equatorial Pacific cores: Rept. Swedish Deep-Sea Exped., v. 6, p. 1-49, 4 pls.

KOURSE, L. D., 1980, Silicoflagellate biostratigraphy of the upper Monterey Formation and lower Sisquoc Formation, Johns-Mansville Quarry, Lompoc, California: Univ. Texas El Paso, unpublished master's thesis, 65 pp., 2 pls., 6 text-figs., 3 tbls.

KÜTZING, F. T., 1844, Die Kieselschligen: Bacillarien oder Diatomeen.

LAUDER, H. S., 1864, On new diatoms: Trans. Micr. Soc. London, v. 12 (n.ser.), p. 6-8.

LEMMERMANN, E., 1901a, Beiträge zur Kenntniss der Planktonalgen: Ber. Deutsche Bot. Ges., v. 19, p. 85-95, pl. 4.

LEMMERMANN, E., 1901b, Silicoflagellatae: Ber. Deutsche Bot. Ges., v. 19, pls. 10-11.

LING, H. Y., 1972, Upper Cretaceous and Cenozoic silicoflagellates and ebridians: Bull. Amer. Paleontology, v. 62, no. 273, p. 135-229, pls. 23-32, 7 text-figs., 1 tbl.

LING, H. Y., 1973a, Silicoflagellates and ebridians from Leg 19: *in* J. S. CREAGER, D. W. SCHOLL *et al.*, Init. Repts. DSDP, v. 19, p. 751-775, 3 pls., 4 text-figs., 14 tbls.

LING, H. Y., 1973b, Radiolaria; Leg 19 of the Deep Sea Drilling Project: *in* J. S. CREAGER, D. W. SCHOLL *et al.*, Init. Repts. DSDP, v. 19, p. 777-797, 2 pls., 13 tbls.

LING, H. Y., 1975, Silicoflagellates and ebridans from Leg 31: *in* D. E. KARIG, J. C. INGLE, JR., *et al.*, Init. Repts. DSDP, v. 31, p. 763-777, 2 pls., 6 text-figs., 7 tbls.

LING, H. Y., 1977, Cenozoic silicoflagellates and ebridians from the eastern North Pacific region: *in* T. SAITO and H. UJIIÉ (eds.), Proc., First Intl. Congr. Pacific Neogene Stratigraphy, Tokyo, 1976, p. 205-233, 3 pls., 10 text-figs.

LING, H. Y., 1980, Silicoflagellates and ebridians from Leg 55: *in* E. D. JACKSON, I. KOISUMI *et al.*, Init. Repts. DSDP, v. 55, p. 375-385, 2 pls., 12 text-figs., 5 tbls.

LOCKER, S., 1974, Revision der Silicoflagellaten aus der Mikrogeologischen Sammlung von G. C. Ehrenberg: Ecologae Geol. Helv., v. 67, p. 631-646, 4 tbls.

LOEBLICH, A. R., III, L. A. LOEBLICH, H. TAPPAN, and A. R. LOEBLICH, JR., 1968, Annotated index of fossil and recent silicoflagellates and ebridians with descriptioins and illustrations of validly proposed taxa: Geol. Soc. America, Mem. 106, p. 1-319, 53 pls., 21 text-figs.

LOHMAN, K. E., 1931, Diatoms from Modelo Formation (Upper Miocene) near Girard, Los Angeles County, California: California Inst. Tech., unpublished master's thesis.

LOHMAN, K. E., 1938, Pliocene diatoms from the Kettleman Hills, California: U. S. Geol. Survey, Prof. Paper 189-C, p. 81-102, pls. 20-23.

LOHMAN, K. E., 1941, Diatomaceae, part 3, *in* W. H. BRADLEY *et al.*, Geology and biology of North Atlantic deep sea cores, between Newfoundland and Ireland: U. S. Geol. Survey, Prof. Paper 196-B, p. 11-17, pls. 12-17.

LOHMAN, K. E., 1948, Middle Miocene diatoms from the Hammond Well, *in* Cretaceous and Tertiary Subsurface Geology: Maryland Dept. Geol., Mines and Water Res., Bull. 2, p. 151-186, pls. 5-11.

LOZANO, J. A., 1974, Antarctic sedimentary, faunal and sea surface temperature responses during the last 230,000 years with emphasis on comparison between 18,000 years ago and today: Columbia Univ., New York, unpublished Ph. D. dissertation, 400 pp.

LYNGBYE, H. C., 1819, Tentamen Hydrophytologiae Danicae Continens omnia Hydrophyta cryptogama Daniae, Holsatiae, Faeroae, Islandiae, Groenlandiae hucusqve cognita, Systmeatice Disposita, Descripta et iconibus illustrata, Adjectis Simul Speciebus Norvegicis: Hafniae, 248 pp., 70 pls.

MANN, A., 19097, Report on the diatoms of the Albatross voyages in the Pacific Ocean, 1888-1904: U. S. Natl. Herbarium, Contr., v. 10, part 5, p. 221-419, 11 pls.

MARTIN, G. C., 1904, Radiolaria, *in* Maryland Geological Survey, Miocene: Johns Hopkins Press, Baltimore, p. 447-459, pl. 130 (plate published separately).

MARTINI, E., 1971, Neogene silicoflagellates from the equatorial Pacific: *in* E. L. WINTERER, W. R. RIEDEL *et al.*, Init. Repts. DSDP, v. 7, p. 1695-1708, 3 text-figs., 4 tbls.

MARTINI, E., and C. MÜLLER, 1976, Eocene to Pleistocene silicoflagellates from the Norwe-

gian-Greenland Sea (DSDP Leg 38): *in* M. TALWANI, G. UDINTSEV *et al.*, Init. Repts. DSDP, v. 38, p. 857-895, 12 pls., 3 text-figs., 5 tbls.

MERTZ, D., 1966, Mikropaläontologische und sedimentologische Untersuchung der Pisco Formation Süderperus: Palaeontographica, v. 118(B), p. 1-51, pls. 1-7, 1 fig., 7 tbls.

MOORE, T. C., JR., 1972, Mid-Tertiary evolution of the radiolarian genus *Calocycletta*: Micropaleontology, v. 18, p. 144-152, 2 pls.

MUCHINA, V. V., 1965, De speciebus diatomearum novis e depositibus partis aequatorialis oceani pacifici [in Russian]: Acad. Sci. SSSR, Inst. Bot. Nomine V. L. Kamarovii, v. 22, Moskau-Leningrad.

MÜLLER, J., 1858, Über die Thalassicollen, Polycystinen und Acanthometren des Mittelmeeres: Abh. Kgl. Akad. Wiss. Berlin, p. 1-62, pls. 1-11.

MURRAY, J., 1876, Challengerida, Preliminary Reports on work done on board the *Challenger*: Proc. Roy. Soc. London, v. 24, p. 471-536, pl. 24.

NESS, G., S. LEVI, and R. COUCH, 1980, Marine magnetic anomaly timescales for the Cenozoic and Late Cretaceous, a précis, critique, and synthesis: Rev. Geophysics Space Physics, v. 18, no. 4, p. 753-770.

NIGRINI, C., 1967, Radiolaria in pelagic sediments from the Indian and Atlantic Oceans: Scripps Inst. Oceanography, Bull., v. 11, p. 1-125, 9 pls., 48 text-figs.

NIGRINI, C., 1970, Radiolarian assemblages in the North Pacific and their application to a study of Quaternary sediments in core V20-130: Geol. Soc. America, Mem. 126, p. 139-175, 4 pls., 43 text-figs., 2 tbls.

NIGRINI, C., 1977, Tropical Cenozoic Artostrobiidae (Radiolaria): Micropaleontology, v. 23, p. 241-269, 4 pls., 2 text-figs.

NIGRINI, C., and T. C. MOORE, JR., 1979, A guide to modern Radiolaria: Cushman Found. Foram. Res., Spec. Publ. 16, xi + 260 pp., 28 pls.

NIGRINI, C., and G. LOMBARI, 1984, A guide to Miocene Radiolaria, Cushman Found. Foram. Res., Spec. Publ. 22, 206 pp., 33 pls.

OBRADOVICH, J. D., and C. W. NAESER, 1981, Geochronology bearing on the age of the Monterey Formation and siliceous rocks in California, *in* R. E. GARRISON and R. G. DOUGLAS (eds.), The Monterey Formation and related siliceous rocks of California: Soc. Econ. Paleont. Mineral., Pacific Sect., p. 87-95.

PANTOCSEK, J., 1886, Beiträge zur Kenntniss der fossilen Bacillarien Ungarns: Marine Bacillarien, pt. l.

PERAGALLO, MM. H., and M. PERAGALLO, 1897-1908, Diatomées Marines de France et des Districts Maritimes Voisins: Micrographe-Éditeur, à Grez-sur-Loing (S.-et-M.) Text, 491 pp. + 48 pp.; Atlas, 137 pls. (pl. 1-24, 1897; 25-48, 1898; 49-72, 1899; 73-80, 1900; 81-96, 1901; 97-110, 112, 113, 1902; 124-131, 1904; 132-135, 1905; 120-124, 136-137, 1907; 114-119 and 111, 1908).

PETRUSHEVSKAYA, M. G., 1967, Radiolarii otriado Spumellaria y Nassellaria antarkticheskoi oblasti: *in* Issled. Fauni Morei, v. 6(12), Rez. Biol. Issled. Sov. Antarct. Exped. 1955-1958, no. 3, p. 5-186, 102 text-figs., 5 tbls.

PETRUSHEVSKAYA, M. G., 1975, Cenozoic radiolarians of the Antarctic, Leg 29, DSDP: *in* J. P. KENNETT, R. E. HOUTZ *et al.*, Init. Repts. DSDP, v. 29, p. 541-675, 44 pls., 10 text-figs., 8 tbls.

PETRUSHEVSKAYA, M. G., and G. E. KOZLOVA, 1972, Radiolaria; Leg 14, Deep Sea Drilling Project: *in* D. E. HAYES, A. C. PIMM *et al.*, Init. Repts. DSDP, v. 14, p. 495-648, 41 pls., 14 tbls.

PISCIOTTO, K. A., 1978, Basinal sedimentary facies and diagenetic aspects of the Monterey Shale, California: Univ. California, Santa Cruz, unpublished Ph. D. dissertation, 450 pp.

POPOFSKY, A., 1908, Die Radiolarien des Antarktis (mit Ausnahme der Tripyleen): Deutsche Südpolar-Exped., 1901-1903, Rept., v. 10 (Zool. v. 2), no. 3, p. 183-305, pls. 20-36, 29 text-figs., 1 tbl.

PRITCHARD, A., 1861, A history of Infusoria, living and fossil: Whittaker and Co., London, edition 4, revised and enlarged, 968 pp., 40 pls.

PROSHKINA-LAVRENKO, A. I., 1949, Diatomovyy analiz, Knigi 2. Opredelitel' iskopaemykh i sovremennykh diatomovykh vodorosley, poryadki Centrales i Mediales: Vses. Nauchno-Issledov, Geol. Inst. Minist. Geol., Bot. Inst. Komarova, Akad. Nauk SSSR, p. 1-238, pls. 1-101.

PROSHKINA-LAVRENKO, A. I., (ed.), 1950, Diatomovyy analiz, Knigi 3. Opredelitel' iskopaemykh i sovremennykh diatomovykh vodorosley, poryadok Pennales: Vses. Nauchno-Issledov, Geol. Inst. Minist. Geol., Bot. Inst. Komarova, Akad. Nauk SSSR, p. 1-398, pls. 1-117.

PROSHKINA-LAVRENKO, A. I., 1960, Diatomeae novae et curiosae e depositu maeotico Maris nigri [in Russian]: Notulae syst. e Sect. Crypt. Inst. Bot. Komarovii, v. 13, p. 54-66, 3 pls.

RALFS, J., 1861, *in* A. PRITCHARD, A history of Infusoria, living and fossil: Whittaker and Co., London, edition 4, revised and enlarged, 968 pp., 40 pls.

RATTRAY, J., 1888a, A revision of the genus *Aulocodiscus* Ehrenberg: Journ. Roy. Micr. Soc., v. 8, p. 337-382, pls. 5-7.

RATTRAY, J., 1888b, A revision of the genus *Auliscus* Ehrenberg: Journ. Roy. Micr. Soc., v. 8, p. 861-920, pls. 12-16.

RATTRAY, J., 1889, A revision of the genus *Coscinodiscus* Ehrenberg and some allied genera: Proc. Roy. Soc. Edinburgh, v. 16, p. 449-692, pls. 1-3.

RATTRAY, J., 1890, A revision of the genus *Actinocyclus* Ehrenberg: Jour. Quekett Micr. Club, (2nd ser.), v. 4, p. 137.

REINHOLD, T., 1937, Fossil diatoms of the Neogene of Java and their zonal distribution: Verh. Geol. Mijnbou. Genootschap, Geol. Ser., v. 12, p. 43-132, 21 pls.

REYNOLDS, R. A., 1980, Radiolarians from the western North Pacific, Leg 57, Deep Sea Drilling Project: *in* R. VON HUENE, N. NASU *et al.*, Init. Repts. DSDP, v. 57, p. 735-769, 1 pl.

RIEDEL, W. R., 1953, Mesozoic and Late Tertiary Radiolaria of Rotti: Journ. Paleontology, v. 27, p. 805-813, pls. 84-85, 1 text-fig.

RIEDEL, W. R., 1957, Radiolaria; a preliminary stratigraphy: Swedish Deep-Sea Exped. 1947-1948, Repts., v. 6, no. 3, p. 59-96, 4 pls., 5 text-figs.

RIEDEL, W. R., 1958, Radiolaria in Antarctic sediments: Repts. B.A.N.Z. Antarct. Res. Exped., ser. B., v. 6, pt. 10, p. 217-255, 4 pls., 13 text-figs., 1 tbl.

RIEDEL, W. R., 1967a, Some new families of Radiolaria: Proc. Geol. Soc. London, no. 1640, p. 148, 149.

RIEDEL, W. R., 1967b, Subclasss Radiolaria, *in* W. B. HARLAND *et al.* (eds.), The Fossil Record: Geol. Soc. London, p. 291-298, text-figs. 8.1A-B.

RIEDEL, W. R., 1971, Systematic classification of Polycystine Radiolaria, *in* B. M. FUNNEL and W. R. RIEDEL (eds.), Micropaleontology of Oceans, Cambridge Univ. Press, Cambridge, p. 649-661.

RIEDEL, W. R., and A. SANFILIPPO, 1970, Radiolaria, Leg 4, Deep-Sea Drilling Project: Init. Repts. DSDP, v. 4, p. 503-575, 15 pls., 3 text-figs., 4 tbls.

RIEDEL, W. R., and A. SANFILIPPO, 1971, Cenozoic Radiolaria from the western tropical Pacific, Leg 7: *in* E. L. WINTERER *et al.*, Init. Repts. DSDP, v. 7, p. 1529-1672, 8 pls., 3 text-figs., 8 tbls.

SABELINIA, M. M., 1934, Die Diatomeen der tertiären Ablagerungen des Ostufers von Kamtschatka: Trudy Neft. Geol. Rasv. Inst., ser. A, v. 48, p. 3.

SAITO, T., 1977, Late Cenozoic planktonic foraminiferal datum levels; the present state of knowledge toward accomplishing pan-Pacific correlation: *in* T. SAITO and H. UJIIÉ (eds.), Proc., First Intl. Congr. Pacific Neogene Stratigraphy, Tokyo, 1976, p. 61-80.

SANFILIPPO, A., and W. R. RIEDEL, 1970, Post-Eocene 'closed' theoperid radiolarians: Micropaleontology, v. 16, p. 446-462, 2 pls., 1 text-fig., 2 tbls.

SANFILIPPO, A., and W. R. RIEDEL, 1973, Cenozoic Radiolaria (exclusive of Theoperids, Artostrobiids and Amphipyndacids) from the Gulf of Mexico, Deep Sea Drilling Project, Leg 10: *in* J. L. WORZEL, W. BRYANT *et al.*, Init. Repts. DSDP, v. 10, p. 475-461, 36 pls., 6 text-figs., 9 tbls.

SANFILIPPO, A., and W. R. RIEDEL, 1980, A revised generic and suprageneric classification of the Artiscins (Radiolaria): Journ. Paleontology, v. 54, p. 1008-1011, 1 text-fig.

SANFILIPPO, A., M. J. WESTBERG-SMITH, and W. R. RIEDEL, *in press*, Cenozoic radiolarian stratigraphy.

SCHMIDT, A., 1874-1959, Atlas der Diatomaceenkunde, v. 1-120: O. R. Resiland, Leipzig, 480 pls.

SCHMIDT, A., 1874, Die in den Grundproben der Nordseefahrt vom 21 Juli bis 9 Sept 1872 enthaltenen Diatomaceen, Erste Folge: Jahresber. Komm. Untersuchung Deutsch Meer., v. 2, 3 pls.

SCHRADER, H. J., 1973a, Cenozoic diatoms from the Northeast Pacific, Leg 18: *in* L. F. MUSICH and O. E. WESER, Init. Repts. DSDP, v. 18, p. 673-797, pls. 1-26, figs. 1-36, tbls. 1-8.

SCHRADER, H. J., 1973b, Stratigraphic distribution of marine species of the diatom *Denticula* in Neogene North Pacific sediments: Micropaleontology, v. 19, p. 417-430, 1 pl.

SCHRADER, H. J., 1974a, Revised diatom stratigraphy of the experimental Mohole drilling, Guadalupe site: California Acad. Sci., Proc., (4th ser.), v. 39, no. 23, p. 517-562, 6 figs., 4 tbls.

SCHRADER, H. J., 1974b, Cenozoic marine planktonic diatom stratigraphy of the tropical Indian Ocean: *in* R. L. FISHER, E. T. BUNCE *et al.*, Init. Repts. DSDP, v. 24, p. 887-967.

SCHRADER, H. J., 1976, Cenozoic planktonic diatom biostratigraphy of the southern Pacific Ocean: *in* C. D. HOLLISTER, C. CRADDOCK *et al.*, Init. Repts. DSDP, v. 35, p. 605-671.

SCHRADER, H. J., 1979, Opal phytoplankton in DSDP Leg 49 samples: *in* B. P. LUYENDYK, J. R. CANN *et al.*, Init. Repts. DSDP, v. 49, p. 589-593.

SCHULZ, P., 1928, Beiträge zur Kenntniss fossiler und rezenter Silicoflagellaten: Bot. Arch., v. 21, p. 225-292, 83 text-figs.

SHESHUKOVA-PORETZKAYA, V. S., 1967, Neogenovye morskie diatomovye vodorosli Sakhalina i Kamchatki: Leningradskii Ordena Lenina Gosudarstvennyi Universitet imeni. A. Zhdanova, Izdatel'stvo Leningradskogo Universiteta, p. 1-432, pls. 1-50.

SIMONSEN, R., 1979, The diatom system; ideas

on phylogeny: Bacillaria, v. 2, p. 9-79.

SIMONSEN, R., and T. KANAYA, 1961, Notes on the marine species of the diatom genus *Denticula* Kützing: Internat. Rev. Ges. Hydrobibiol., v. 46, p. 498-513.

SMITH, W., 1852, Notes on the Diatomaceae with descriptions of British species included in the genus *Pleurosigma*: Ann. Mag. Nat. Hist., (ser. 2), v. 9, p. , 2 pls.

SMITH, W., 1853-1856, Synopsis of British Diatomaceae: John Van Voorst, London, v. 1, 89 pp., pl. 1-31 (1853); v. 2, 107 pp., pl. 32-60; supplementary pls. 61, 62, pls., A-E (1856).

STAINFORTH, R. M., *et al.*, 1975, Cenozoic planktonic foraminiferal zonation and characteristics of index forms: Univ. Kansas Paleontol. Contr., Art. 62, p. 1-425.

STÖHR, E., 1880, Die Radiolarien-Fauna der Tripoli von Grotte (Provinz Girgenti in Sicilien): Palaeontographica, v. 26, p. 69-124, pls. 17-23.

STRADNER, H., 1961, Über fossile Silicoflagelliden und die Möglichkeit ihrer Verwendung in der Erdölstratigraphie: Erdöl und Kohle, v. 14, p. 87-92, 3 pls., 1 text-fig.

TAN, Z., and T. R. TCHANG, 1976, Studies on the radiolarians of the East China Sea II, Spumellaria, Nassellaria, Phaeodaria, Sticholonchea: Studia Marina Sinica, no. 11, p. 217-310, 3 pls., 81 text-figs.

TEMPÈRE, J., and H. PERAGALLO, 1907-1915, Diatomées du monde entier: Arcachon, Grez-sur-Loing (S.-et-M.), 480 pp., 68 pls.

THEYER, F., C. Y. MATO, and S. R. HAMMOND, 1978, Paleomagnetic and geochronologic calibration of latest Oligocene to Pliocene radiolarian events, Equatorial Pacific: Marine Micropaleontology, v. 3, p. 377-395, 2 pls.

TSUMURA, K., 1963, A systematic study of Silicoflagellatae: Yokohama Municipal Univ., Journ., v. C-45, no. 146, p. 1-84, 28 pls., 4 text-figs.

VAN HEURCK, H., 1880-1885, Synopsis des diatomées de Belgique: Anvers, Text, 235 pp., 3 pls.; Atlas, 3 pp., 132 pls. (1880-1881).

VAN HEURCK, H., 1896, A treatise on the Diatomaceae: William Wesley and Son, London, 558 pp., 35 pls., 291 figs.

VAN LANDINGHAM, S. L., 1967-1971, Catalogue of the fossil and recent genera and species of diatoms and their synonyms, parts 1-4; J. Cramer, Lehre, 2385 pp.

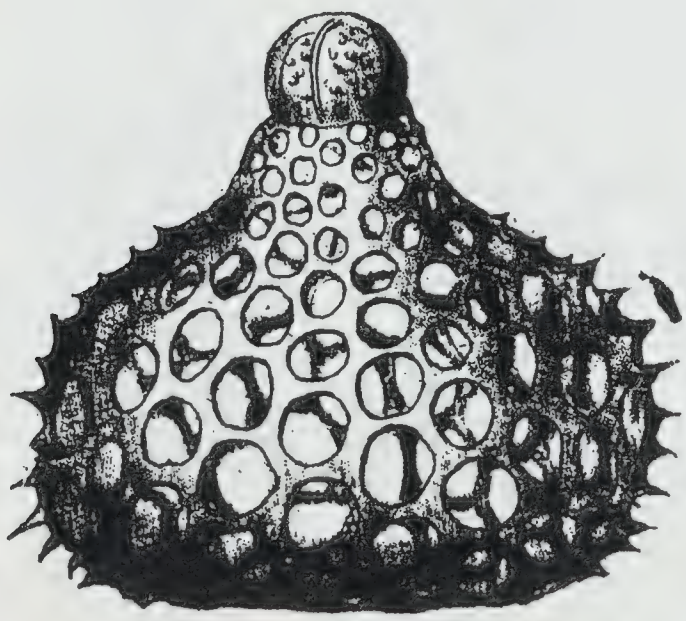
WALLICH, G. C., 1860, On the siliceous organisms found in the digestive cavities of the Salpae, and their relation to the flint nodules of the Chalk Formation: Trans. Micr. Soc. London, v. 8 (n.ser.), p. 36, pl. 2.

WEAVER, F. M., R. E. CASEY, and A. M. PEREZ, 1981, Stratigraphic and paleoceanographic significance of Early Pliocene to Middle Miocene radiolarian assemblages from northern to Baja California, *in* R. E. GARRISON and R. G. DOUGLAS (eds.), The Monterey Formation and Related Siliceous Rocks of California, Los Angeles, California: Soc. Econ. Paleont. Mineral., Pacific Sect., Proc., p. 71-86, 6 pls., 3 text-figs., 4 tbls.

WOLFART, R., 1981, Neogene radiolarians from the eastern North Pacific (off Alta and Baja California), Deep-Sea Drilling Project Leg 63: *in* R. S. YEATS, B. U. HAQ *et al.*, Init. Repts. DSDP, v. 63, p. 473-506.

WOODRING, W. P., and M. N. BRAMLETTE, 1950, Geology and paleontology of the Santa Maria district, California: U. S. Geol. Survey, Prof. Paper 222, 185 pp., 23 pls., 9 text-figs.

WORNARDT, W. W., JR., 1967, Miocene and Pliocene marine diatoms from California: California Acad. Sci., Occasional Paper 63, 108 pp., 217 figs.



TULANE STUDIES IN GEOLOGY

VOLUME 1, Complete with title page and contents $7.00

VOLUME 2, Complete with title page and contents $7.00

VOLUME 3, Complete with title page and contents $10.00

VOLUME 4, Complete with title page and contents $10.00

VOLUME 5, Complete with title page and contents $10.00

VOLUME 6, Complete with title page and contents $10.00

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

VOLUME 7, Complete with title page and contents $12.00

VOLUME 8, Complete with title page and contents $12.00

VOLUME 9, Complete with title page and contents $12.00

VOLUME 10, Complete with title page and contents $15.00

VOLUME 11, Complete with title page and contents $15.00

VOLUME 12, Complete with title page and contents $15.00

VOLUME 13, Complete with title page and contents $15.00

VOLUME 14, Complete with title page and contents $18.00

VOLUME 15, Complete with title page and contents $18.00

VOLUME 16, Complete with title page and contents $18.00

VOLUME 17, Complete with title page and contents $20.00

(see earlier issues for individual listing)

Vol. 18, Nos. 1, 2, THE WALL STRUCTURE OF SUPERFAMILY MILIOLACEA AND ITS LINEAGE IN THE GULF COASTAL PLAIN, by H. V. Andersen; EVALUATION OF THE FORAMINIFERAL GENERA *CONGLOBATOIDES* AND *CONGLOPHRAGMIUM*, by D. Haman and R. W. Huddleston; STATUS OF THE FORAMINIFERAL SUBGENUS *MICROFASCIOLITES* GAEMERS, 1978, by D. Haman; PLANKTIC FORAMINIFERA AND CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY OF THE NEOGENE OF MEXICO, PART II – LOWER PLIOCENE, by W. H. Akers; NOTES ON THE GENUS *AGNOCARDIA* (MOLLUSCA:CARDIIDAE) WITH THE DESCRIPTION OF A NEW SPECIES FROM THE PLIOCENE OF FLORIDA, by H. E. Vokes; A NEW SPECIES OF *TURBINELLA* (MOLLUSCA:GASTROPODA) FROM THE PLIOCENE OF MEXICO, WITH A REVISION OF THE GEOLOGIC HISTORY OF THE LINE, by E. H. Vokes; THE GENUS *HARPA* (MOLLUSCA:GASTROPODA) IN THE NEW WORLD, by E. H. Vokes; A REVISION OF THE TEREBRID GASTROPODS OF THE MARE FORMATION, CABO BLANCO, VENEZUELA, by J. Gibson-Smith and W. Gibson-Smith; REVIEW OF *POSTLIGATA*, A LATE CRETACEOUS PELECYPOD, by D. Nicol and D. S. Jones; CHANGES IN THE HINGE TEETH OF ARCACEANS FROM DEVONIAN TO RECENT, by D. Nicol; *CHIONE (CHIONE) CRASPEDONIA* DALL IN THE CRYSTAL RIVER FORMATION (EOCENE) IN PENINSULAR FLORIDA, by D. Nicol and D. S. Jones; LYELL'S PROPOSAL OF THE TERM "PLEISTOCENE," by N. J. Whitcomb and W. J. Miller III; FOSSIL HACKBERRY SEEDS FROM THE LOESS AT NATCHEZ, MISSISSIPPI, by W. J. Miller III and L.S.C. Leitch: pp. 1-92 (October 31, 1984) – BOUND TOGETHER. $12.00

Vol. 18, Nos. 3, 4. THE FLANNER BEACH FORMATION (MIDDLE PLEISTOCENE) IN EASTERN NORTH CAROLINA, and A NEW SPECIES OF *GOULDIA* (MOLLUSCA:BIVALVIA) FROM THE PLEISTOCENE OF EASTERN NORTH CAROLINA, by William Miller, III; ECOLOGY AND STRATIGRAPHY OF THE ECHINOIDS OF THE OCALA LIMESTONE (LATE EOCENE), by Melvin Croft and Graig D. Shaak; OBSERVATIONS AND RECOMMENDATIONS ON THE FOSSIL DINOCYST GENERA *CTENIDODINIUM*, *DICHADOGONYAULAX*, AND *KORYSTOCYSTA*, by Don G. Benson, Jr.; *AMMOPEMPHIX LACUSTRIS* N.SP. (FORMANINIFERIDA) FROM LAC DES ALLEMANDS, LOUISIANA, by D. Haman and R. E. Marolt; ON A REDUNDANT GENERIC ASSIGNMENT OF *TEXTULARIA FLORIDANA* CUSHMAN, 1922, and *LIPPSINA*, A NEW NAME FOR *NONIONOIDES* SCHÄFER, 1980, *NON* SAIDOVA, 1975 (FORAMINIFERIDA), by Drew Haman; NOTES ON THE FAUNA OF THE CHIPOLA FORMATION – XXVII: ON THE OCCURRENCE OF THE BIVALVE GENUS *NUCINELLA* WOOD, – XXVIII: ON THE OCCURRENCE OF THE NON-MARINE GENUS *MYTILOPSIS* (MOLLUSCA:BIVALVIA) and – XXIX: A NEW SPECIES OF *PANOPEA* (MOLLUSCA:BIVALVIA), by Harold E. Vokes: pp. 93-168 (December 5, 1985) – BOUND TOGETHER. $12.00

VOLUME 18, Complete with title page and contents $20.00

Vol. 19, Nos. 1, 2. THE CALCAREOUS NANNOPLANKTON OF THE MIDWAY GROUP (PALEOCENE) OF ALABAMA, by David Reimers; TAPHONOMIC CHARACTERISTICS OF OFFSHORE MOLLUSK SHELLS, SAPELO ISLAND, GEORGIA, by Robert W. Frey and James D. Howard; AN EVALUATION OF THE TAXA *MURICOPSIS* AND *RISOMUREX* (GASTROPODA:MURICIDAE), WITH ONE NEW SPECIES OF *RISOMUREX* and A NEW SPECIES OF *MURICOPSIS (RISOMUREX)* FROM WEST AFRICA, by Emily H. Vokes and Roland Houart; NEW SPECIES OF *BATHYSIPHON* (FORAMINIFERIDA:TEXTULARIINA) FROM FRANCISCAN FLYSCH DEPOSITS, NORTHERNMOST CALIFORNIA, by William Miller, III; PUBLICATION DATES OF HEILPRIN'S EXPLORATIONS ON THE WEST COAST OF FLORIDA, by Richard E. Petit and Druid Wilson, pp. 1-96 (July 31, 1986)– BOUND TOGETHER. $12.00

Vol. 19, Nos. 3, 4. COMMUNITY REPLACEMENT IN ESTUARINE PLEISTOCENE DEPOSITS OF EASTERN NORTH CAROLINA, by William Miller, III; OSTRACODE BIOSTRATIGRAPHY AND PALEOECOLOGY OF THE PLIOCENE OF THE ISTHMIAN SALT BASIN, VERACRUZ, MEXICO, by Maria L. Machain-Castillo; FRESH AND BRACKISH WATER OSTRACODA FROM THE NEOGENE OF NORTHERN VENEZUELA, by W. A. van den Bold; MYTILIDAE (MOLLUSCA:BIVALVIA) FROM THE CHIPOLA FORMATION, LOWER MIOCENE, FLORIDA and AN UNUSUAL DISTORTED *SPONDYLUS* FROM THE MOIN FORMATION (PLEISTOCENE), COSTA RICA, by Harold E. Vokes; NOTES ON THE FAUNA OF THE CHIPOLA FORMATION-XXX: ON THE PRESENCE OF *EUDOLIUM (GALEODOLIUM) SUBFASCIATUM* SACCO (GASTROPODA:TONNIDAE), by Emily H. Vokes; EARLY PLIOCENE *MONTFORTELLA* (FORAMINIFERIDA) FROM ECUADOR, by Drew Haman and Barry Kohl; *KARRERIELLA OBTURACULOIDES*, A NEW AGGLUTINATED BENTHIC FORAMINIFERAL SPECIES and *AMPLECTODUCTINA*, A NEW FORAMINIFERAL GENUS, IN THE SIPHOGENERINODIDAE, by R. Timothy Patterson; pp. 97-191 (December 15, 1986) – BOUND TOGETHER $12.00

VOLUME 19, Complete with title page and contents $20.00

VOLUME 20, Subscription $20.00

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 20, Number 4 December 31, 1987

TAXONOMIC INDEX TO VOLUMES 11 THROUGH 20

EMILY H. VOKES
TULANE UNIVERSITY

p. 113

SMITHSONIAN
MAR 14 1988
LIBRARIES

TULANE UNIVERSITY OF LOUISIANA

New Orleans

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY is devoted primarily to the geology and paleontology of the coasts and adjacent land areas of the Gulf of Mexico and the Caribbean Sea. Each number contains an individual monographic study, or several minor studies. As volumes are completed, title pages and tables of contents will be distributed to subscribers and institutions exchanging the entire series.

Manuscripts submitted for publication are evaluated by the editors and for longer papers by an editorial committee selected from the field of the author(s). Contributors need not be members of the Tulane University faculty.

Manuscripts should be submitted on good paper, as original typewritten copy, double-spaced and carefully corrected. Two carbon copies in addition to the original will help expedite editing and assure more rapid publication.

The cost of excessive illustrations and tabular matter may be charged to the author, and will be computed on the cost above that of a normal 10-point page of text.

An abstract not exceeding three percent of the length of the original article must accompany each manuscript submitted. This will be transmitted to any abstracting journal specified by the writer.

Separate numbers or volumes may be purchased by individuals. Subscriptions are not accepted from institutions publishing comparable series; exchange agreements are invited. Authors may obtain copies for personal use at cost.

Address all communications concerning manuscripts and editorial matters, subscriptions, and orders for individual numbers to the editor. Address exchange inquiries to the exchange director.

When citing this series, authors are requested to use the following abbreviations: *Tulane Stud. Geol. Paleont.*

Price for this number, $5.00

Hubert C. Skinner, *Editor*
Emily H. Vokes, *Editor*
and *Exchange Director*
Tulane Studies in Geology and Paleontology
Department of Geology
Tulane University
New Orleans, Louisiana 70118
U.S.A.

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 20, Number 4 December 31, 1987

TAXONOMIC INDEX TO VOLUMES 11 THROUGH 20

EMILY H. VOKES
TULANE UNIVERSITY

Listed below are all biologic names to be found in the second ten volumes of this journal. All species-group names are cited equally, even though in the text they may appear as subspecies. Included are all primary references, such as systematic discussions, illustrations, and diagrams. However in any paper a species may appear many times, therefore all primary references are listed but not the secondary references. If there is no primary reference for a species, in most cases the first appearance of the name then appears in the Index. Abstracts and charts are not indexed, as it is assumed that the species name appears elsewhere in the text. The Roman numeral indicates the volume number and all new taxa are printed in bold-face type, including the page where the original description is given.

A

AALTOI, *Bathysiphon* **XIX 92**, *XIX 93*
abies, Sphenolithus XI 119, XV 13, XV 28, XVI 146, XVIII 26, XIX 130
Abra aequalis XVII 104, XIX 108
absicata, Weisbordella XVIII 130
absona, Murexiella XI 148
abyssicola, Aspella (Dermomurex) XI 148
abyssicola, Dermomurex (Trialatella) XI 146, XI 148
abyssicola, Murex XI 148
abyssicola, Murex (Pterynotus) XI 148
Acanthocardia XIII 152, XVI 5
aculeata XVIII 37
propeciliare XIII 146, XIII 152, XIII 178
Acanthocardia (Acanthocardia) XVI 16
aculeata XVI 14, XVI 18
Acanthocardia (Agnocardia) XVI 16, XVIII 37
sorrentoensis XVI 16
Acanthocardia (Europicardium) XVI 18
multicostata XVI 18
Acanthocardia (Rudicardium) XVI 18
tuberculata XVI 18
Acanthocardia (Schedocardia) XVI 18
hatchetigbeensis XVI 14
Acanthocardium XVI 5
Acanthochiton granulata XVI 63
Acanthocythereis
sp. XVII 34
washingtonensis XVII 34
ACANTHODESMIIDAE *XX 20*
Acanthotrophon XII 118, XIV 131
carduus XIV 132
sentus XII 118, XIV 131
sorenseni XIV 132
sorensoni XII 118
striatus XIV 132
Acaranina densa XI 11
accordionata, Latouchella XVI 72
acervalis, Planorbulina XI 294
Achomosphaera XII 177
sp. XVII 37
ACHROCHORDIELLA XVI 129
VOKESI XVI 130, *XVI 133, XVI 138*
Achrochordoia XVI 129
ACHROCHORDONIIDAE *XVI 129*
acicula, Creseis XVII 102
acicularis, Nautilus (Lituus) XI 278
acicularis, Spirolina XI 278, XI 290
aciformis, Fusus XIII 196
aclinense, Cardium XVI 7
aclinensis, Cardium XVI 7
acostaensis, Globoquadrina XV 10
acostaensis, Globorotalia XV 10
acostaensis, Neogloboquadrina XVIII 26
acostaensis acostaensis, Globorotalia (Turborotalia) XV 10, XV 20, XVI 145
acostaensis humerosa, Globorotalia (Turborotalia) XV 10, XV 22, XVI 146
acostaensis pseudopima, Globorotalia (Turborotalia) XV 10, XV 22, XIX 130
acrocome, Agnocardia XIII 146, XIII 153, XVIII 38, XVIII 40
acrocome, Cardium XIII 153, XVIII 40
acrocome, Cardium (Acanthocardia) XIII 153, XVIII 40
acrocome, Trachycardium (Agnocardia) XIII 153
Acropora
cervicornis XIII 122
palmata XIII 124, XIII 128
acropora, Turritella XIX 61
Acrosterigma XIII 160, XVI 5
inconspicuum XIII 162
Acrosterigma (Acrosterigma) XVI 18
dalli XIII 160, XIII 182, XVI 20, XVI 22
Acrosterigma (Ovicardium) XVI 18

rossi XVI 22
Acrosterigma (Regozara) XVI 18
olivifer XVI 28
Acrosterigma (Vasticardium)
elongatum XIII 161, XIII 182
HOERLEORUM *XIII 154,* **XIII 162,** *XIII 182*
Acteocina canaliculata XVII 102, XIX 108
ACTEOCINIDAE *XVII 102*
Acteon punctostriatus XVII 102
ACTEONIDAE *XVII 102*
Actiniscus decapetalus XI 199
ilvensis XI 199
vernandi XI 199
Actinocyclus XX 40
asteriscus XX 41, XX 44
cholnokyi XX 40, XX 44
cubitus XX 40, XX 44
curvatus XX 40, XX 44
divisus XX 40
ehrenbergii XX 40, XX 44
ellipticus XX 41, XX 44
ingens XX 41, XX 44
moronensis XX 41, XX 44
ochotensis XX 41, XX 44
oculatus XX 41, XX 44
tenella XX 41, XX 44
Actinocythereis XII 81
davidwhitei XII 82
exanthemata cf. XIV 152
exanthemata gomillionensis XII 81
gibsonensis XII 82
gomillionensis XII 81, XII 86, XIX 138
sp. cf. gomillionensis XIX 138
subquadratus XII 81
triangularis XII 81, XIV 152
VANDENBOLDI XII 81, *XII 86*
vineyardensis XIX 138
Actinomma XX 12
spp. XX 12, XX 14
ACTINOMMIDAE *XX 12*
actinophora, Actinotrophon XII 119
Actinoptychus XX 41
bismarckii XX 41, XX 46
clevei XX 41, XX 46
halionyx XX 41, XX 46
incisa XX 41, XX 46
monicae XX 41, XX 46
splendens XX 41
stella XX 41
undulatus XX 41, XX 46
vulgaris XX 41
actinoptychus, Stephanogonia XX 60
Actinotrophon XII 119, XIV 131
actinophora XII 119
aculeata, Acanthocardium XVIII 37
aculeata, Acanthocardia (Acanthocardia) XVI 14, XVI 18
aculeata, Patella XI 166
aculeatum, Cardium XIII 152, XVI 5, XVIII 37
acuminata, Deflandrea XII 195
acuminatum, Eucyrtidium XX 30
acuminata, Isabelidinium XVII 28
acuminata, Proparacytheridea XIX 155
acuta, Nuculana XVII 102, XVIII 120, XIX 108
acuticostata, Ranella XI 125
acuticostatus, Dermomurex XI 127
acuticostatus, Murex XI 130
Acuticythereis multipunctata XIV 145
ACUTUS, *Ceratolithus* **XI 115,** *XI 116, XVIII 33*
acutus, Nassarius XVII 101
adamas, Zygodiscus XIX 32
adamsi, Seila XVII 100
adamsii, Murex XI 138, XII 45
adelae, Cancellaria XII 34
Adiantum capillus-veneris XIII 60
Admetula XII 38
BAYERI *XII 36,* **XII 38**
deroyae XII 39
evulsa XII 38
VOSSI *XII 36,* **XII 39**
zapoteca XII 39
Adnatosphaeridium sp. XVII 37
advena, Discocyclina XI 181
advena, Polystomella XI 290
advena, Rectobolivina XI 282, XVI 92
advena, Siphogenerina XI 282
advenum, Elphidium XI 290, XI 296
adversarius, Conus XVI 97
aedificatum, Vasum XV 112
aequa, Truncorotataloides (Morozovella) XII 237
aequale, Cardium XVI 36
aequalica, Cypria XIX 148
aequalis, Abra XVII 104, XIX 108
aequalis, Cypria XIX 147
aequalis, Osculapollis XVII 36
aequilateralis, Globigerina XV 12
aequilateralis, Hastigerina XVI 94
aequilateralis involuta, Globigerina XV 12
aequistriata, Tellina XVII 103, XIX 61
aerolata, Manicina XIII 122
Aesculiidites circumstriatus XVII 39
affinis, Melonis XVIII 32
affinis, Nodosaria XVII 35
Africofragum XVI 5
Afrocardium XVI 5
Agaronia XVI 106
Agassizia XVIII 135
clevei XVIII 132
agassizii, Agatrix XII 38
agassizii, Trigonostoma XII 38
Agatrix XII 38
agassizii XII 38
deroyae XII 39
epomis XII 36, XII 38
strongi XII 39
agglutinans, Ammobaculites XI 271
agglutinans, Quinqueloculina XI 274
agglutinans, Spirolina XI 271
agglutinans, Textularia XI 272, XI 280
Agnocardia XIII 153, XVI 5, XVIII 37, XVIII 43
acrocome XIII 146, XIII 153, XVIII 38, XVIII 40
alternata XVIII 42
cinderellae XVIII 42
claibornense XVI 5
convexum XVIII 37
dissidepictum XVIII 42

glebosum XVIII 38
n. sp.? XVIII 40
pessoae XVIII 42
SPINOSIFRONS *XVIII 38*, **XVIII 43**
agria, Peristichia XVII 102
Agriopoma texasiana XVII 104
aguadillensis, Orthaulax XIV 128, XV 110
Ailanthipites berryi XVII 28
AKERSI, CRIBROLENTICULINA XIV 90, *XIV 19, XIV 96, XIV 98, XIV 100*
AKERSI, *Globorotalia* **XI 302,** *XI 304, XIV 32, XIV 66, XIV 78*
alabamensis, Hantkenina XII 148
alabamensis, Turritella XIX 2
alabamensis, Voorthuyseniella XII 146, XII 148, XII 150, XII 152, XII 157
alabamicus, Choanopollenites XVII 39
alabaster, Murex XI 138, XII 45
alabastrum, Dermomurex XII 46
alabastrum, Dermomurex (Dermomurex) XII 45
alabastrum, Murex XI 138, XII 45
Alangiopollis XVII 27
sp. XVII 29
alaquaensis, Poirieria (Panamurex) XII 103
alata, Dorcadospyris XX 6
alata, Purpura XVI 46
alata, Ranella XI 96
alata cf., Rhizosolenia XX 58
alatum, Cytheropteron XII 64
alatum, Endopachys XI 173
alatus, Chiphragmalithus XI 11
alatus, Murex XVI 46
alatus, Strombus XVI 97, XVII 101, XIX 61
alatus, Typhis XVII 124
alatus, Typhis (Talityphis) XVII 124, XVII 126
alatus obesus, Typhis (Talityphis) XVII 125
alba, Anadonta XVI 97
alba, Anodontia XVII 103
alba, Cardium XVI 6
albatrossi, Bolivina XVI 92
albatrossi, Nodosaria XVI 92
albicilla, Nerita XVII 132
Albula XV 99
sp. XV 100, XV 102
ALBULIDAE *XV 102*
Aldanella XVI 71
attleborensis XVI 73
aldrichi, Echinolampas XVIII 130
aldrichi, Phalium XIX 177
aldrichi, Phalium (Semicassis) XIX 177
aldridgei, Attiliosa XII 124, XII 126, XIV 132
aldridgei, Vasum XII 124
aldrovandi, Panopea XVIII 166
alexanderi, Cytheretta XII 89
alfredensis, Murex XVI 48
alfredensis, Pygmaepterys XVI 52
alfredensis cf., Pygmaepterys XVI 52
alicula, Cardium (Trigoniocardium) XIII 172
aliculum, Cardium XII 172
Aligena texasiana XVII 103
alleni, Cibicides XVII 35
ALLENI, *Dimya* **XV 38,** *XV 40*
alleni, Nucinella XVIII 162
Allioraphium XVI 125
Allomorone XV 99
sp. XV 100, XV 103
Allomophina XIX 182
Alnus vera XVII 29
alophia, Pterygocythereis XIX 139
alternans, Ericsonia XI 195
alternata, Agnocardia XVIII 42
alternata, Tellina XVII 103
alticostata, Venericardia XI 181
altilis, Orthaulax XV 108
altispira, Globigerina XV 10
altispira, Globoquadrina XIV 9
altispira altispira, Globoquadrina XV 10, XV 18, XVI 145, XVIII 26
altispira globosa, Globoquadrina XV 10, XV 18, XVIII 26
altus, Micrantholithus XI 189, XI 220
alumen, Cardium (Cerastoderma) XIII 186
alumen, Dinocardium XIII 186
alumensis, Trigonostoma XII 44
alveatus, Murex XI 122, XI 140, XIX 63
Alvellodinium XVIII 152
falsificum XVIII 152
Alveolina
boscii XVIII 20
pulchra XI 279
ALVEOLINIDAE *XI 279, XVIII 3*
Amaurolithus
delicatus XVIII 29, XVIII 35
primus XVIII 29, XVIII 35
tricorniculatus XVIII 33
ambitacrena, Tinophodella XVIII 34
Amblypygus americanus XVIII 130
Ambocythere
campana XIX 155
caudata XIX 138
sp. cf. sp. A XIX 138
AMBONA, *Basterotia (Basterotia)* **XVI 160,** *XVI 163*
AMBONOS, *Conus* **XII 13,** *XII 14*
americana, Enaeta XIV 115
americana, Harpa XVI 155, XVI 156, XVII 57, XVIII 54, XVIII 56
americana cf., Harpa XVII 57, XVIII 56
americana, Mitreola XIV 115
americana, Pseudopyxilla XX 56, XX 58
americana, Pterygocythereis XII 85, XII 90
americana, Rhizosolenia XX 56
americana strattoni, Truncatulina XI 300
americana, Strigatella XIV 115
americanus, Amblypygus XVIII 130
americanus, Cibicides XV 5
americanus, Mastodon XV 59
Americardia XIII 184, XVI 5
amiantus, Linga XVII 103
amica, Circe XVIII 124
Ammobaculites XI 271
agglutinans XI 271
salsus XI 271
AMMODISCACEA *XIX 92*
Ammonia XI 288
beccarii XVI 92, XIX 131

beccarii parkinsoniana XI 288, XI 296
beccarii tepida XI 290, XI 296
parkinsoniana XI 288, XVI 94
pauciloculata XVI 94
tepida XI 290, XVI 94
Ammopemphix XVIII 157
arctica XVIII 157
LACUSTRIS XVIII 157, *XVIII 158*
quadrupla XVIII 157
Ammotium XI 271
salsum XI 271
Amphicardium XVI 5
amphiceros, Rhaphoneis XX 56
Amphicoryna
camachoi XVI 92
roederi XVI 94
Amphimorphina stainforthi XVIII 32
AMPHINEURA *XVI 56, XVI 61*
Amphistegina XI 294, XV 7, XIX 182
gibbosa XVI 94
lessoni var. XV 5
lessonii XI 88, XI 294, XVI 94
AMPHISTEGINIDAE *XI 294*
Amphitetras elegans XX 66
amphitheatralis, Discolithina XI 34, XI 210
amphitrite, Balanus XVI 104
amphitrite obscurus, Balanus XVI 104
amphitrite venustus, Balanus XVI 104
amphixiphos, Xiphoditua XX 16
amphora, Fromea XII 216, XII 226
Amphorospaeridium XII 185
bipolare XII 188
ampla, Saracenaria XVI 92
AMPLECTODUCTINA XIX 190
CARNATOLINTRA *XIX 189,* **XIX 190**
amplexum, Pharciceras XVII 49
amplificatus, Ceratolithus XI 115, XI 116
amplus, Blackites XI 40, XI 42, XI 46,XI 226
Ampullina fischeri XI 99
Amusium ocalanum XII 140
Amussium XV 44
amygdala, Aurila XIV 143
amygdala sp. cf., Aurila XIV 143, XIV 148
amygdala, Hemicythere XIV 143
Anabarella XVI 75
Anachis
obesa XVII 101
semiplicata XVII 101
Anadara XVIII 71
brasiliana XVII 102
ovalis XVII 102, XIX 61
transversa XVII 102, XIX 61, XIX 108
Anadonta
alba XVI 97
schrammi XVI 97
Anaticinella XI 306
multiloculata XI 306
Anatipopecten XVIII 73
Anatolepis XVII 40
anceps, Aspella XI 126, XI 132, XI 134
anceps, Ranella XI 124
Anchippus XV 59
ancyla, Kangarina XIX 139
Andalusiella polymorpha XVII 37
anderseni, Cytheretta XIX 139
anderseni, Loxoconcha XIV 146
Andreaea XVI 138
ANDREWSI, *Calotrophon* **XII 110,** *XII 122*
andromeda, Quercus XIII 60
ANEUROS, *Conus* **XII 10,** *XII 14*
angelina, Stylosphaera XX 13
angelinum, Axoprunum XX 13, XX 14
ANGELLI, *Strioterebrum XVIII 62,* **XVIII 65**
angolensis, Muricopsis XIX 80
angolensis, Ocenebra XIX 86
Anguilla XV 99
sp. XV 100, XV 102
ANGUILLIDAE *XV 102*
ANGUILLIFORMES *XV 102*
angularis difformis, Clavulina XI 272
angulata, Globorotalia XIX 11
angulata, Oliva XVI 107
angulata, Spiroloculina XI 273
angulata, Truncorotataloides (Morozovella) XII 237
angulata, Turbinella XVIII 48, XVIII 50
angulata, Voluta XVIII 51
angulatum, Epitonium XVII 100
angulatum, Pemma XI 46, XI 50, XI 191
angulatus, Archaias XI 278, XI 290
angulatus, Nautilus XI 278
Angulogerina bella XI 284
anguloluminosus, Retitrescolpites XVII 30
angulosa, Grammatophora XX 50, XX 54
angulosa, Mussa XIII 116
angulosus, Micrantholithus XI 189, XI 191, XI 216
angustus,Rhoipites XVII 29
ANIMALIA *XV 102*
Anisoconchus fortunatus XV 85
Anisodonta (Basterotia)
bowdeniana XVI 160
quadrata XVI 158
Anisodonta corbuloidea XVI 162
anna, Voluta XIV 113
annetorpense, Fibradinium XII 214, XVII 37
annetorpense cf., Fibradinium XII 214, XII 222
anniae, Murex XI 141
annula, Cyclolithella XI 119
annula, Emiliania XV 13, XV 26, XVIII 26
annularis, Montastrea XIII 124
annulatus, Cyclococcolithus XI 195
annulatus, Momipites XVII 29
annulatus, Ophiraphidites XVI 129
annulus, Coccolithites XV 13
annulus, Cyclolithella XV 13
Anodontia alba XVII 103
anodosus, Conus XII 26
Anomalina midwayensis XVII 35
ANOMALINIDAE *XI 300*
ANOMALININAE *XI 300*
Anomalinoides nucleatus XVI 94
Anomalocardia auberiana XVII 104
Anomia
obliqua XV 50
simplex XVII 102, XIX 61

ANOMIIDAE *XVII 102*
Anomocytheridea
locketti XIV 140
ANOPTOS, *Falsilyria XIV 124*, **XIV 127**
Antarctissa XX 18
denticulata XX 18, XX 20
sp. XX 20
ANTECESSOR, *Dermomurex (Trialatella)* **XI 145**, *XI 146*
Antenor XIV 88
antepenultima, Didymocyrtis XX 6
Anthocyrtidium XX 28
ehrenbergi XX 28
ophirense XX 28
Anthocyrtis ophirensis XX 28
ANTHOZOA *XI 173*
antillarum angulata, Spiroloculina XI 273, XI 282
antillarum, Articulina XI 277
antillarum, Diadema XIII 114, XIII 126
antillarum, Eponides XIX 131
antillarum, Eupatagus XVIII 131
antillarum, Lithodomus XIX 169
antillarum, Lithophaga XIX 166, XIX 169
antillarum, Lithophaga (Lithophaga) XIX 169
antillarum, Neoeponides XI 88, XVI 92
antillarum, Spiroloculina XI 273, XI 282, XVI 92
antillarum, Trigoniocardia XIII 177
antilleana, Pseudocandona XIX 147
Antillophyllia chipolana XIII 170, XIX 172
Antipathes XIII 113
sp. XIII 118
antiqua, Floridina XII 141
antiqua, Thalassionema XX 62
antiqua, Thalassiosira XX 62
antiquum, Eudolium XIX 177
antiquus, Coscinodiscus XX 43, XX 50
antonius, Dermomurex (Viator) XI 150, XI 154
aoteanum, Eudolium XIX 179
apanthesma, Truncorotataloides (Morozovella) XII 237
apateticum, Trigoniocardia XIII 180
Apectodinium homomorphum cf. XVII 37
apenninicus, Latirus (Dolicholatirus) XIII 196
aperta, Fulva XVI 6
aperta, Calyptraea (Trochita) XI 163, XI 164
aperta, Discolithina XI 210
Apertapetra XI 28
samodurovi XI 29, XI 198
umbilicata XI 21, XI 198
apertum, Cardium XVI 6, XVI 41
apertum, Laevicardium (Fulvia) XVI 36
apertum, Papyridea XIII 164
apertura, Globigerina XV 10
Aphera islacolonis XV 106
Aphrodite XVI 5
apicina, Marginella XVII 101
Apiocardia XIII 172, XVI 5
APLACOPHORA *XVI 56, XVI 61*
apodensata, Venericardia XV 71
Aporrhais XI 96
aposmithii, Venericardia XV 71
appendiculata, Lithophaga XIX 170
appendiculata, Modiola XIX 170
appendiculata, Stephanopyxis XX 60
APPRIMUS, *Crepipatella* **XI 168**
aquitanicum, Vasum XV 113
AQUOREUS, *Conus* **XII 17**, *XII 22*
arachnea, Siphocampe XX 32, XX 34
arachnoidea, Riddellia XIII 61
Arachoidiscus XX 42
decorus XX 42, XX 46
ehrenbergii XX 42, XX 46
montereyanus XX 42, XX 46
ornatus XX 42
aradasii, Murex XIX 87
aragonensis, Globorotalia XI 11
aragonensis, Hantkenina XI 11
Araliaceoipollenites
granulatus XVII 29
profundus XVII 29
Arca XVIII 70
modiolus XIX 161
ARCACEA *XVIII 70*
ARCAFORMA, *Gregariella XIX 162*, **XIX 168**
Archaeopteryx XVI 58
Archaias XI 278
angulatus XI 278, XI 290
compressus XI 278
ARCHAIASINAE *XI 278*
ARCHEOGASTROPODA *XI 103*
archerensis, Neolaganum XVIII 130
Archicardium XVI 5
Arcinella cornuta XVII 103, XIX 61
arctica, Ammopemphix XVIII 157
ARCTICIDAE *XVI 9*
arcticum, Triceratum XX 64, XX 66
Arctopratulum XVI 5
arcuata, Balcis XVII 101
arcuatus, Typhis XVII 128
Arcullaea XVIII 68, XVIII 71
ARCULLAEINAE *XVIII 68*
arenata, Spiroloculina XI 273, XI 282
arenosa, Birkelundia XI 12
areolatata cf., Systematophora XII 226
Areoligera XII 204
sp. XII 204, XII 220
arestum, Cardium XIII 178
argentea, Dimya XV 49
Argilloecia XII 60, XVI 86
cyclindrica XII 60
minor XII 60
posterotruncata XII 60, XII 66, XIX 138
Argobuccinum XI 96
boutillieri XI 96
argo, Chicoreus (Chicoreus) XI 90
argo, Murex XI 90
argo, Murex (Chicoreus) XI 90
Argopecten
gibbus XVII 102, XIX 61
irradians concentricus XVII 102
arietinus, Nautilus (Lituus) XI 278
arietinus, Spirolina XI 278
ARIIDAE *XV 96*
Ariosoma sp. XV 100, XV 102
aristata, Lithophaga (Myoforceps) XIX 170

Aristerospira pachyderma XIV 35
Arius XV 99
sp. XV 100, XV 102
Arkhangelskiella cymbiformis XVII 32
arlus, Dermomurex (Trialatella) XI 128, XI 146
arlus, Murex XI 128
armatus, Murex XIX 86
armatus, Muricopsis XIX 86
armiger, Paraster XVIII 130
armigera, Cornulina XVI 150
armigerus, Melongena XVI 150
Articulina XI 277
antillarum XI 277
lineata XI 277
mayori XI 277, XVI 94
mucronata XI 277
multilocularis XI 277, XI 288
sagra XI 277, XI 288
ARTOSTROBIIDAE *XX 30*
Artostrobium
auritiuum XX 32
miralestense XX 32
rhinoceros cf. XX 34
ASCENSUS, *Calotrophon* **XII 110**, *XII 122*
Asclepias drakeana XIII 29
ashermani, Cushmanidea XII 62
ashermani, Cytherideis XII 62, XIV 141
ashermani, Hulingsina XII 62, XII 70, XIV 141, XIV 148
ashermani, Pontocythere XII 62, XIV 141, XIX 134
Ashtarotha XVI 165
asiaticum, Vepricardium XVI 38
asketogonium, Lithodesmium XX 52, XX 56
Aspella XI 124, XIII 102
anceps XI 126, XI 132, XI 134
bakeri XI 141
cantrainei XII 45
decurrens XI 125
elizabethae XI 141
engonata XI 136
engonatus XI 136
hastula XI 132, XI 134
paupercula XI 140
pauperculum varians XII 45
pauperculus XI 140
producta XI 145
pygmaea XI 125
pyramidalis XI 126, XI 134
scalarioides XI 136
scalarioides lamellosa XI 141
scalarioides obeliscus XI 140
scalarioides paupercula XI 140
senex XI 123, XI 132, XI 134
sp. XI 126, XI 134
subanceps XI 125
varians XI 140, XII 45
Aspella (Aspella)
engonata XI 136
scalarioides XI 148
senax XI 132
Aspella (Dermomurex)
abyssicola XI 148
elizabethae XI 141
engonatus XI 136
pauperculus XI 140
Aspella (Takia)
sexangula XI 152
asper, Tricolpites XVII 39
aspera, Dictyocha XX 85
asperrima, Henryhowella XII 84
asperrima, ex. gr., Henryhowella XII 84, XII 90, XIX 139
aspinosa, Thalassiosira XX 62
ASTARTACEA *XVI 8*
Astarte XV 39, XVI 41, XVI 165
crenalirata XVI 42
distans floridana XVI 167
undulata XVI 165
Astarte (Ashtarotha)
floridana XVI 167
PANSYRTA XVI 165, *XVI 166*
sp. XVI 165
ASTARTIDAE *XVI 165*
ASTEIGERINIDAE *XVIII 18*
aster, Discoaster XI 56, XI 58
Asterigerina XI 6, XI 288
carinata XI 288, XI 294, XI 296
texana XI 181
ASTERIGERINIDAE *XI 286, XVIII 18*
asteriscus, Actinocyclus XX 41, XX 44
asteriscus, Dermomurex (Viator) XI 153, XI 154
asteriscus, Murex XI 131
Asterocyclina XII 141, XVIII 73
asteroides, Porites XIII 122
asteromphalus, Coscinodiscus XX 44, XX 50
Asteromphalus XX 42
darwinii XX 42, XX 46
Astraea sp. XIII 122
Astrangia sp. XIX 113
Astrononion XI 298
stelligerum XI 298
Astrophyton XIII 113
astroporus, Cyclococcolithus XI 196, XIX 28
astroporus, Markalius XI 196, XIX 24, XIX 28
ASTRORHIZACEA *XVIII 157*
ASTRORHIZIDAE *XIX 92*
asymmetrica, Deflandrea XII 191, XII 208
asymmetricum, Callaiosphaeridium XVII 28
asymmetricus, Discoaster XI 120, XV 13, XV 26
ATAXOPHRAGMIACEA *XIX 185*
ATAXOPHRAGMIIDAE *XI 272*
Athleta XV 73
haleanus XV 73
petosus XV 73
symmetricus XV 73
toumeyi XV 73
atkinsi, Pellucistoma XIV 152
atkinsi sp. aff., Pellucistoma XIV 152
atlantica, Lamarckina XI 300
atlantica, Munseyella XII 80
atlantica, Neritopsis XI 176
atlantica, Nodobaculariella XVI 92
atlantica, Reussella XI 88, XI 284
atlanticus, Florilus XVI 92
atlanticus, Tretomphalus XI 284, XVI 92

atlantis, Murex XII 102
atlantoides, Pelagiella XVI 73
atractus, Conus XII 25
atratum, Cerithium XIX 61
Atreta XV 35
Atrina serrata XVII 102
atropos, Moira XIX 53
atrostyla, Kurtziella XVII 102
attenuata, Muricidea XII 105
Attiliosa XI 122, XII 111, XII 134, XIV 131
  aldridgei XII 124, XII 126, XIV 132
  caledonica XIX 86
  carduus XII 118
  incompta XII 116, XII 134, XIV 132
  noduliferus XIX 87
  nodulosa XII 134, XIV 132
  orri XIX 87
  philippiana XII 111, XII 120, XII 126, XIV 131
  phillipiana XIV 132
  striata XII 111, XII 114, XII 124, XII 126, XIV 132
attleborensis, Aldanella XVI 73
Aturia curvilineata XII 14
ATYIDAE *XVII 102*
aubergiana, Quinqueloculina XI 274
aubergina laevis, Uvigerina XI 284
auberiana, Anomalocardia XVII 104
Aulacodiscus XX 42
  concentricus XX 42, XX 46
  kittonii XX 42, XX 48
  margaritaceus XX 42, XX 48
  simplex XX 42, XX 48
Aulacomya XIX 161
Auliscus XX 42
  caelatus XX 42, XX 48
  constricta XX 42, XX 48
  punctatus XX 42, XX 48
aurea, Zygosphaera XI 242
aureliana, Dyopteris XIII 61
aureliana, Oscillaria XIII 61
aureus, Orthozygus XI 224, XI 242
aureus, Zygolithus XI 242
auri, Corculum (Trigoniocardia) XVI 36
auriculata, Planispira XI 273
auriculata, Wiesneriella XI 273, XI 282
Aurila XII 69, XIV 143, XVI 86
  amygdala XIV 143
  amygdala sp. cf. XIV 143, XIV 148
  BELLEGLADENSIS XIV 143, *XIV 150*
  conradi XIX 134
  conradi californica XIV 144
  conradi floridana XII 69, XIV 143
  conradi littorala XII 69
  floridana XII 69, XII 78, XIV 143, XIV 150
  littorala XII 69
  sp. XIX 138
aurita, Biddulphia XX 42, XX 48
auritium, Artostrobium XX 32
auritum, Diatoma XX 42
auritus/australis, Botryostrobus XX 30
ausonia, Dictyocha XX 86
Australiella XII 200
australiensis, Riberia XVI 74
australina, Svalbardella XII 197, XII 226
australinum cf., Palaeocystodinium XVII 37
australis, Entopyla XX 50
australis, Globulina XI 279
australis, Guttulina XI 279
australis, Loxoconcha XII 73
australis, Neomophila XIII 61
australis, Xenikoon XII 224, XII 228
Austrotrillina XVIII 14
AUTODERMARIA *XVI 136*
avellana, Loxoconcha XII 74
avenatus, Typhis XVII 128
aventi, Postligata XVIII 68
Avicennia germinans XII 107
Awadia XVI 6
awaensis, Vaginulina XIV 94
Axinactis XVIII 67
Axinola XVIII 67
axonense, Cardium XVI 7
axonense, Jurassicardium XVI 30, XVI 32
Axoprunum XX 13
  angelinum XX 13, XX 14
ayalai, Pumilocytheridea XII 60

B

Bachmannocena triangula XX 94
Bacteriastrum XX 42
  sp. XX 42, XX 48
Bactrites spp. XVII 48
baculoferus, Favitricolporites XVII 39
Baculostephanocolpites sp. A. XVII 36
baggi, Vaginulinopsis XIV 94
bahamensis, Cythere XII 81
BAILEYI, *Voorthuyseniella* **XVI 87,** *XVI 88*
bainbridgensis, Chione (Chione) XVIII 74
Bairdia
  bradyi XIV 139
  crosskeiana XIV 139
  foveolata XIV 139
  gerda XIV 139, XIX 132
  longisetosa sp. aff. XIX 138
  sp. XVII 34
  suborbiculata XVII 34
BAIRDIACEA *XII 58, XIV 137*
BAIRDIIDAE *XII 58, XIV 137*
BAIRDIINAE *XII 58*
Bairdoppilata XIV 137
  carinata XIV 137
  sp. XIX 138
  triangulata XIV 137
  victrix sp. aff. XIX 138
Bairdoppilata (Bairdoppilata)
  cushmani XIV 137, XIV 140
bajocensis, Cryptocardium XVI 6, XVI 32
bakeri, Aspella XI 141
BALANIDAE *XVI 98*
BALANOMORPHA *XVI 98*
Balanus XIX 55
  amphitrite XVI 104

amphitrite obscurus XVI 104
amphitrite venustus XVI 104
eburneus XVI 99
concavus proteus XVI 97
NEWBURNENSIS XVI 100, *XVI 102*
sarasotaensis XVI 99, XVI 100
sp. XVI 108
talquinensis XVI 98
venustus venustus XVI 104
Balcis
arcuata XVII 101
gracilis XVII 101
jamaicensis XVII 101
balium, Pemma XI 190, XI 214
Baltisphaeridium
bifidum XII 185
centrocarpum XII 189
colligerum XII 184
ferox XII 186
placacanthum XII 228
bambergensis, Nodosaria XIX 191
barbadiensis, Discoaster XI 56, XI 59, XI 61, XI 62, XI 198, XI 232
barbadiensis, Heliodiscoaster XI 199
barbata, Brizalina XVI 92
barbatellus, Modiolus XIX 168
barboi, Pyxilla XX 58
barboi, Rhizosolenia XX 58, XX 60
barkeri, Cytheropteron XIX 139
barleeana, Nonionina XI 298
barleeanum, Nonion XI 298
barleeanus, Melonis XVI 92
Barnea truncata XVII 104
barnesae, Tergestiella XIX 28
barnesii, Enaeta XIV 115
barnesii, Voluta XIV 114
barnsii, Voluta XIV 114
bartonensis, Krithe XII 61
Basiliomya XV 34
goreaui XV 34
basilium, Palaeoperidinium XII 196, XII 216
basilium, Peridinium XII 196
basiloba, Nonionella XVI 92
Basilosaurus XV 56
Basopollis obscurocostata XVII 30
basquense pemma XI 48, XI 50, XI 190, XI 192, XI218
basquense crassum, Pemma XI 46, XI 50, XI 52, XI 191, XI 218
basquensis, Micrantholithus XI 50, XI 190, XI 191
basquensis, Pemma XI 190, XI 191
basquensis crasus, Micrantholithus XI 51, XI 191
bassendorfensis, Buliminella XVII 46
bassendorfensis sp. cf., Buliminella XVII 46
bassensis, Triloculina XI 275, XI 286
bassleri, Cytheretta XIX 139
Basslerites XII 89, XIV 154, XIX 155
berchoni XII 89, XII 92
cuspidatus XII 90
minutus XII 90, XIV 154, XIX 138, XIX 155
miocenica XIV 155
miocenicus XII 90
sp. XIV 154, XIX 138
VOKESI *XII 78*, **XII 89**, *XIV 155*
Basterotella XVI 161
floridana XVI 158
pustula XVI 157
Basterotia XVI 160
corbuloides XVI 160
granatina XVI 161
oblonga XVI 157
prima XVI 160
quadrata XVI 160
Basterotia (Basterotia)
AMBONA XVI 160, *XVI 163*
peninsularis XVI 158
Basterotia (Basterotella)
bowdeniana XVI 162
elliptica XVI 162
hertleini XVI 159
MIOCENICA XVI 161, *XVI 163*
basteroti, Terebra XVIII 61
BASTEROTIIDAE *XVI 160*
Bathymurex XII 102
Bathyropyramis XX 20
woodringi XX 20, XX 22
Bathysiphon XIX 92
AALTOI XIX 92, *XIX 93*
carapitanus XIX 93
sakuensis XIX 93
BAYERI, *Admetula XII 36*, **XII 38**
beauii, Lyria XIV 111
beccarii, Ammonia XVI 92, XIX 131
beccarii parkinsoniana, Ammonia XI 288, XI 296
beccarii parkinsoniana, Rotalia XI 288
beccarii tepida, Ammonia XI 290, XI 296
beccari tepida, Rotalia XI 290
beckeri, Schizaster XVIII 130
beckmanni, Orbulinoides XI 11
belcheri, Cardium XVI 8
belcheri, Trachycardium XIII 154
belcheri, Trachycardium (Phylogcardia) XVI 20, XVI 28
bella, Angulogerina XI 284
bella inepta, Marginella XI 308
bella, Marginella XI 308
bella, Trifarina XI 284, XI 292, XVI 92
bellastriata, Semele XVII 104
BELLEGLADENSIS, *Aurila* **XIV 143**, *XIV 150*
bellula, Uvigerina XI 284, XI 292, XVI 92
berberum, Cardium XIII 172
berberum, Cardium (Trigoniocardia) XIII 172
berchoni, Basslerites XII 89, XII 92
berchoni, Cythere XII 89
bermudae, Cythere XIV 145
bermudae, Orionina XIV 145
bermudezi **LOUISIANENSIS**, *Munseyella* **XII 80**, *XII 86, XIX 139*
bermudezi, Munseyella XII 80
bermudezi, Triloculina XI 275, XI 286
BERMUDEZI, *Xestoleberis XIX 152*, **XIX 156**
bernayi, Cheilea XI 170
berryi, Ailanthipites XVII 28
berryi, Eutrephoceras XII 238, XII 240

bertheloti, Discopulvinulinella XVI 92
BERYCIFORMES *XV 103*
betsiae, Trigonostoma XII 44
Betula
infrequens XVII 39
sp. XVII 29
Betulaceoipollenites sp. XVII 36
Biantholithus sparsus XIX 8
bicarinata, Triloculina XI 275, XVIII 3
bicatenatus, Ergalatax XIX 70
Bicatillus (Desmaulus) XI 165
bicaveata, Discolithina XI 206, XI 240
bicelliforma, Perissocytheridea XIX 139
bicolor, Murex XI 141
bicolor, Trigonaphera XII 40
Bicornifera XVI 81
bicornis, Pterocorys XX 26
bicornis, Theocalyptra XX 26
bicostata, Quinqueloculina XI 274, XVI 92
Biddulphia XX 42
aurita XX 42, XX 48
obtusa XX 42, XX 48
rhombus XX 43, XX 48
suborbicularis XX 43, XX 48
tridens XX 43, XX 48
bidens, Chiasmolithus XI 15, XI 16, XI 22,XI 194, XIX 8
bidens, Coccolithus XI 15
bidentata, Quinqueloculina XI 274
bidentatus, Melampus XVII 102
biexcavatus, Lithodomus XIX 170
Bifarina turriformis XI 8
bifidum, Baltisphaeridium XII 185
bifidum, Exochosphaeridium XII 185, XII 202
Bifissurinella XVI 82
biformis, Callianassa XVII 93
bigelowi, Braarudosphaera XI 42, XI 45, XI 46, XI 119, XI 187, XI 212, XVII 31, XIX 20, XIX 40
bigelowi, Pontosphaera XI 45, XI 187, XIX 40
Bigenerina XI 272
irregularis XI 272
bijugatus, Zygolithus XI 71
bijugatus, Zygrhablithus XI 45, XI 66, XI 71, XI 72, XI 244, XI 246
bilineatus, Eulima XVII 101
bilobata, Biobulina XV 10, XV 16, XVI 145, XVIII 24
bilobata, Globigerina XIV 50, XV 10
bilobata, Orbulina XIV 24, XIV 50, XIV 56, XV 10
Biloculina
carinata XI 275
comata XI 275
subsphaerica XI 275
Biloculinella toddae XVI 94
binodosus, Discoaster XI 56, XI 59, XI 60, XI 62, XI 199, XIX 9
binodosus hirundinus, Discoaster XI 56, XI 60, XI 62, XI 199
Biorbulina bilobata XV 10, XV 16, XVI 145, XVIII 24
biornatum, Eudolium XIX 177
bipolare, Amphorosphaeridium XII 188
bipolare, Cordosphaeridium XII 188
bipolare, Fibrocysta XVII 28
bipolare, Lanternosphaeridium XII 188, XII 206
bipolaris, Florianella XVI 61
biradiatus, Coscinodiscus XX 44, XX 50
Birkelundia XI 12
arenosa XI 12
jugata XI 12, XI 22, XI 194
staurion XI 22, XI 195
biscaynense, Teinostoma XVII 100
Biscutum dimorphosum XIX 36
bisecta, Dictyocha XX 86
bisecta, Reticulofenestra XI 197, XI 228
bisecta, Syracosphaera XI 197
bisectus, Coccolithus XI 197
bisectus, Dictyococcites XI 197
biseriata, Melosira XX 52, XX 56
biseriata, Paralia XX 52
bismarckii, Actinoptychus XX 41, XX 46
bisotensis, Murex XI 148
bispicatus, Distephanus XX 92, XX 94
bisulcata, Lithophaga (Diberus) XIX 166, XIX 170
bisulcatus, Lithodomus XIX 170
bisulcus, Coccolithus XIX 36
Bittium XIX 83
Bitulogenerina vicksburgensis XII 143
BIVALVIA *XI 101, XI 105, XII 47, XII 161, XII 163, XV 33, XVI 1, XVI 56, XVII 47, XVII 102, XVIII 123, XVIII 161, XVIII 163, XVIII 165, XIX 61, XIX 159*
Bivetiella [see Cancellaria (Bivetiella)] XII 34
Bivetopsia XII 40
Blackites XI 40, XI 224
amplus XI 40, XI 42, XI 46, XI 226
creber XI 38, XI 41, XI 200, XI 224
hayi XI 236
incompertus XI 228
rectus XI 40, XI 226
scabrosus XI 38, XI 41
sp. A XI 208, XI 230
spinosus XI 40, XI 202, XI 204, XI 224, XI 226
spinulus XI 226
tenuis XI 38, XI 42, XI 206, XI 224, XI 226, XI 228
TROCHUS *XI 210* **XI 230**
blainvillei, Murex XII 104, XIX 66, XIX 85
blainvillei, Muricopsis XIX 86
blainvillei, Muricopsis (Muricopsis) XIX 70
BLOWI, *Oliva (Oliva?)* **XVI 109,** *XVI 110*
blowi cf., Oliva XVI 110, XVI 112
boehmi, Dimyodon XV 51
böhmi, Dimyodon XV 51
Bolboforma XVI 81
boldi, Cytheridella XIX 150, XIX 154
Bolinus [see also Murex (Bolinus)] XI 153
boliviensis, Dictyocha XX 88
boliviensis, Distephanus XX 88, XX 92
Bolivina XI 282, XIX 182
albatrossi XVI 92
goesii XI 282
hastata XI 282
lanceolata XI 282, XI 292

lowmani XI 282
mexicana XVI 168
pauli XI 282
porrecta XI 296
primitiva XI 284
pulchella primitiva XI 284
rhomboidalis XI 282
striatula XI 282
subaenariensis XV 6
subaenariensis mexicana XVI 168
tortuosa XI 296
Bolivina (Brizalina)
HAMANI XVI 168
HAMANI *aliformis* **XVI 168**
HAMANI HAMANI XVI 168
HAMANI *horizontalis* **XVI 168**
mexicana XVI 168
subaenariensis mexicana XVI 168
BOLIVINETIDAE XI 282
Bolivinita XI 282
rhomboidalis XI 282, XI 292
Bollis heterophylla XIII 61
Bombacacidites
reticularis XVII 38
sp. XVII 36
bombayanus, Lataxiena XIX 86
bombayanus, Murex XIX 86
bonneti, Dimya XV 49
Boonea XVII 105
borderlandensis, Mesocena XX 94
borealis, Coscinodiscus XX 46, XX 52
borealis, Ostrea XV 44
Borelis XI 279
pulchra XI 279
Boreotrophon XII 119, XIV 131
echinus XII 120
borneensis, Voorthuyseniella XII 158, XIII 138
bosciana, Quinqueloculina XI 274, XI 280
boscii, Alveolina XVIII 20
boscii, Oryzaria XVIII 20
Bostrycapulus XI 166
bostrychites, Spondylus XIV 128, XIX 174, XIX 175
Botryostrobus XX 30
auritus/australis XX 30
bramlettei XX 30
miralestensis XX 32
miralestensis sp. cf. XX 30, XX 32
Botula XIX 172
fusca XIX 162, XIX 172
Botulina XIX 168
boulangeri, Discoaster XI 61
boutillieri, Argobuccinum XI 96
boutillieri, Cheilea XI 170
bowdenensis, Lenticulina XVI 92
bowdenensis, Poirieria (Pazinotus) XII 110
bowdenensis, Strioterebrum XVIII 64
bowdeniana, Anisodonta (Basterotia) XVI 160
bowdeniana, Basterotia (Basterotella) XVI 162
Braarudosphaera XI 45, XI 187, XIX 40
bigelowi XI 42, XI 45, XI 46, XI 119, XI 187, XI 212, XVII 31, XIX 20, XIX 40
cheloma XI 188, XI 212
discula XI 42, XI 48, XI 188, XVII 31, XIX 8
irregularis XI 188, XI 212
orthia XI 189
parvula XI 189
rosa XI 188, XI 212
stylifer XI 188, XI 214
turbinea XIX 22, XIX 40
BRAARUDOSPHAERACEAE *XI 45, XI 187, XIX 40*
Brachidontes XIX 161
curtulus XIX 161, XIX 162
exustus XVII 102
Brachydontes XIX 161
Brachyodontes XIX 161
brachys, Murex XIX 86
Bradleya normani XIX 138
bradyi, Bairdia XIV 139
bradyi, Cytheridea (Haplocytheridea) XIV 140
bradyi, Gaudryina XIX 186
bradyi, Globigerina XV 13
bradyi, Haplocytheridea XIV 140, XIV 146
bradyi, Hauerina XI 277, XI 288
bradyi, Karreriella XIX 186
bradyi, Orionina XIV 145
bradyi, Peneroplis XI 277, XI 288
bradyi cf., Haplocytheridea XII 70, XII 93
bradyi sp. cf., Paranesidea XIV 139, XIV 146
bramlettei, Botryostrobus XX 30
bramlettei, Discoaster XI 204
bramlettei, Lithomitra XX 30
bramlettei, Marthasterites XIX 9
bramlettei, Montfortella XIV 103, XIX 183
Bramletteius serraculoides XI 9, XI 186
bramletti, Campylosphaera XI 192
brasiliana, Anadara XVII 102
braunsi, Cardium XVI 6
braunsi, Clinocardium (Fuscocardium) XVI 38
brazieri, Murex XIX 86
brazieri, Murexsul XIX 86
Brazosiella sp. XV 100, XV 103
brechincastrensis, Strioterebrum XVIII 65
Bregmaceros XV 99
troelli XV 100, XV 102
BREGMACEROTIDAE *XV 102*
Brevicardium XVI 6
fragile XVI 6
Breviocolporites
sp. XVII 36
brevifrons, Chicoreus (Chicoreus) XI 84
brevifrons, Murex XII 45
brevispina, Dictyocha XX 86, XX 90
brevisulcatum, Chrysophyllum XVII 28
Brissopsis
elongata XVIII 135
luzonica XVIII 135
lyrifera XVIII 135
steinhatchee XVIII 135
bristolae, Calotrophon XII 105
Brizalina XIX 182
barbata XVI 92
fragilis XVI 94
spinata XVI 94
Broeckina XI 278

orbitolitoides XI 278, XVI 94
bromia, Thrysocyrtis XX 34
bronni, Fusus XIII 196
bronni, Turbinella XIII 196
Brotzenia XVIII 150
brouweri, Discoaster XI 80, XI 120, XV 13, XV 26, XVI 146, XVIII 26
brueggeni, Cardium XVI 8
brueggeni, Vepricardium (Perucardia) XVI 16
buelowi, Clinocardium XVI 38
bryani, Eutrephoceras XII 238, XII 240
Bucardium XVI 6
Buccella hannai XVI 94
BUCCINACEA *XVI 149*
BUCCINIDAE *XVII 101*
Buccinum
evulsa XII 38
geversianum XII 104, XIV 131
harpa XVIII 56
scabriculum XII 34
Buchia XIX 91
Buchiola XVII 48
retrostriata XVII 47, XVII 48
bukowskii, Cardium XVI 43
Bukryaster XII 166
hayi XII 168
OZANENSIS XII 166
bulbosa, Liochlamys XII 116
bulbosa, Papyridea XIII 158, XIII 165, XIII 178
bulbosum, Cardium (Papyridea) XIII 165
bulbosus, Micrantholithus XI 51
bulbosus, Pemma XI 48, XI 51, XI 52, XI 191
Bulimina XI 282, XVII 46, XIX 182
compressa XI 296
elegantissima XI 280
marginata XI 282, XI 292, XVI 94
spicata XI 284
spicata cf. XI 284
tenuis XVI 94
williamsoniana XI 280
BULIMINACEA *XI 280, XIX 190*
Buliminella XI 280, XVII 46
bassendorfensis XVII 46
bassendorfensis sp. cf. XVII 46
elegantissima XI 280, XI 290
milletti XI 280, XI 292
mississippiensis XVII 46
morgani XVII 46
BULIMINIDAE *XI 282*
BULIMININAE *XI 282*
Buliminoides XI 280
williamsoniana XI 280, XI 292
bullata, Cancellaria XII 42
bullatum, Cardium XIII 164
bullatum, Trigonostroma (Ventrilia) XII 42
bullatus, Solen XIII 164
BULLISI, *Chicoreus (Chicoreus)* **XI 91,** *XI 92*
bulloides, Globigerina XI 119, XIV 15, XIV 16, XV 10, XVI 94
bulloides, Sphaeroidina XVI 92
bulloides apertura, Globigerina XV 10, XV 16, XVIII 30, XIX 131
bulloides bulloides, Globigerina XV 10, XV 16, XVI 146, XVIII 24
bulloides dehiscens, Sphaeroidina XIV 52
bumeliaefolia, Quercus XIII 60
Buntonia XII 84, XVI 86
garretti XII 84
sp. XII 84, XII 86, XIX 138
BUNTONIINAE *XII 84*
burmudensis, Gouldia XVIII 124
burnsii, Cardium (Fragum) XIII 181
burnsii, Trigoniocardia (Americardia) XIII 181
burnsii, Trigoniocardia (Trigoniocardia) XIII 166, XIII 174, XIII 181
Bursa XI 97
lamellosa XI 126
pelouatenis XI 156
buryanus, Stictodiscus XX 60
Busycon
carica sp. cf. XIX 108
perversum pulleyi XVII 101
spiratum plagosum XVII 101
spp. XVIII 117, XIX 108
byramensis, Miliola XVIII 8
byramensis, **NEAGUITES** *XVIII 12, XVIII 15*
byramensis, Quinqueloculina XVIII 8
byramensis, Spiroloculina XVIII 15
Bythocythere tenuissima XII 76
BYTHOCYTHERIIDAE *XII 60*

C

caboblanquensis, Trigoniocardia XIII 180
cabrilloensis, Clathrocyclas XX 22
CAECIDAE *XVII 100*
Caecum
imbricatum XVII 100
johnsoni XVII 100
caelatus, Auliscus XX 42, XX 48
cagigalensis, Hemicyprideis XIX 152
calathus, Chiphragmalithus XI 66, XI 70
calcar, Lenticulina XVI 92
Calcarata XII 35
calcifer, Spondylus XIX 168
calcitrapa, Murex (Chicoreus) XI 88
Calcocyclas margatensis XX 28
caledonica, Attiliosa XIX 86
caledonica, Muricidea XIX 86
calhounensis, Cytheretta XII 89
calhounensis, Murexiella XI 156
calida, Globigerina XIV 16, XIV 34, XIV 38, XV 10, XVIII 22
calida, Globigerinella XVIII 34, XIX 127
calida praecalida, Globigerina XV 10, XV 16,XVIII 34
california, Dimya XV 49
californica, Danea XVII 37
californica, Nitzschia XX 54, XX 58
californica, Rouxia XX 58, XX 60
californicum, Cladogramma XX 43, XX 50
californicus, Chiasmolithus XIX 22, XIX 26
californicus, Coccolithus XIX 22

californicus, Stictodiscus XX 60, XX 62
californiense, Cardium XVI 7
californiense, Clinocardium (?Keenocardium) XVI 28
californiense, Corculum (Keenocardium) XVI 40
Callaiosphaeridium asymmetricum XVII 28
Callianassa biformis XVII 93
callida, Reticulofenestra XI 197, XI 240
callidus, Dictyococcites XI 197
Calliostoma XI 168, XIX 78
Callistocythere XIX 155
MACSOTAYI *XIX 150,* **XIX 155**
Calocyclas hannai XX 28
callopleurum, Cardium (Fragum) XIII 177
Calocycletta costata XX 6
Calotrophon XI 122, XII 105
ANDREWSI XII 110, *XII 122*
ASCENSUS XII 110, *XII 122*
bristolae XII 105
hutchisoni XII 103
ostearum XII 105, XII 112, XII 114, XII 116, XII 118, XII 120, XII 134
ostrearum conradi XII 109, XII 114
Calotrophon (Attiliosa) philippiana XII 120
calvertense, Eucyrtidium XX 24
calvertense sp. cf., Eucyrtidium XX 22, XX 24
Calyptraea XI 170
costaria XI 165
crenata XI 165
floridana XI 165
greensboroensis XI 166
ornata XI 165
spirata XI 165
trochiformis XI 163
uncinata XI 171
CALYPTRAEIDAE *XI 163, XVII 101*
Calyptraea (Trochita) XI 163
aperta XI 163,XI 164
costaria XI 164, XI 165, XI 166
crenata XI 165, XI 166
ornata XI 164, XI 165, XI 166
spirata XI 163
trochiformis XI 163, XI 164
Calyptraphorus XV 72
stamineus XV 72
trinodiferus XV 72
velatus XV 72
velatus compressus XV 72
velatus nodovelatus XV 72
Calyptrolithus morionum XI 238
camachoi, Amphicoryna XVI 92
camerina, Stylodicta XX 16
campana, Ambocythere XIX 155
campana, Pacambocythere XIX 148, XIX 155
campanulata, Codonia XII 183
campbelli, Olssonella XII 36
campechiensis, Mercenaria XVII 104
CAMPYLOCYTHERINAE *XIV 145, XIX 155*
Campylosphaera
bramletti XI 192
dela XI 21, XI 192, XI 226
eodela XI 193
canaliculata, Acteocina XVII 102, XIX 108
canaliculatus, Turbo XI 168
canariensis, Haplophragmoides XI 271
canariensis, Nonionina XI 271
Cancellaria XII 33
adelae XII 34
bullata XII 42
centrota XII 35
conradiana XII 34
costata XII 40
dalli XII 42
evulsa XII 38
goniostoma XII 40
propevenusta XVI 97
reticulata XII 34, XVII 101
reticulata adelae XII 34
reticulata cf. XII 33, XII 36
rigida XII 40
similis XII 34
smithii XII 35
tenera XII 42, XII 44
trochilia XII 35
CANCELLARIACEA *XII 33*
Cancellaria (Bivetiella) cancellata XII 34
Cancellaria (Sveltia) **GLADIATOR XII 35,** *XII 36*
CANCELLARIIDAE *XII 33, XVII 101*
cancellariiformis, Murex XI 130
cancellarioides, Murex XI 130
cancellarius, Cantharus XVII 101
cancellata, Cancellaria (Bivetiella) XII 34
cancellata, Chione XVII 104
cancellata, Exogyra XII 176
cancellata, Voluta XII 34
cancellosa, Cythereis XVII 34
Cancris sagra XVI 94
candeiana, Rosalina XI 286, XI 294, XVI 92
Candeina XIV 54
nitida XIV 26, XIV 54, XIV 60, XV 11, XVI 94, XVI 146
nitida nitida XV 11, XV 14, XVIII 24
CANDEINIDAE *XIV 54*
Candona XII 59
lactea XII 59
marchina cf. XII 66, XII 93
patzcuaro cf. XII 66, XII 93
sp. XII 59, XII 66
CANDONIDAE *XII 59, XIX 147*
Cannopilus XX 85
sphaericus XX 85, XX 86
sp. XX 85, XX 86
Cannosphaeropsis XII 183
canoasensis vidali, Mytilus XIX 161
Cantharus cancellarius XVII 101
Cantharus (Pollia)
multigranosus XIX 74, XIX 81
subsinuatus XIX 81
turricula XIX 81
Cantharus (Pseudosalpinx)
floridana XII 106
perplexus XII 106
cantrainei, Aspella XII 45
cantrainei, Triton XI 138, XII 45
capillus-veneris, Adiantum XIII 60

Caprifoliipites tantulus XVII 29
carapitanus, Bathysiphon XIX 93
Cardamine ludoviciana XIII 61
Cardea XVI 6
CARDIACEA *XVI 16, XVI 43*
Cardiarius XVI 6
CARDIIDAE *XIII 152, XVI 9, XVI 16, XVII 103, XVIII 37*
CARDIINAE *XIII 152, XVI 9, XVI 16, XVIII 43*
Cardissa XVI 6
cardissa, Cardium XVI 6
cardissa, Corculum XVI 22, XVI 24
Cardita XVI 41
dupiniana XVI 42
CARDITIDAE *XVI 41*
Cardium XVI 6
aclinense XVI 7
aclinensis XVI 7
acrocome XIII 153, XVIII 40
aculeatum XIII 152, XVI 5, XVIII 37
aequale XVI 36
alba XVI 6
aliculum XIII 172
apertum XVI 6, XVI 41
arestum XIII 178
axonense XVI 7
belcheri XVI 8
berberum XIII 172
braunsi XVI 6
brueggeni XVI 8
bukowskii XVI 43
bullatum XIII 164
californiense XVI 7
cardissa XVI 6
carolinum XVI 7
ciliatum XVI 6
conjugens XVI 41
convexum XVIII 37
costatum XVI 6, XVI 14, XVI 18
cumingii XVI 7
dalli XIII 160, XVI 5
discors XVI 6
discrepans XVI 6
donaciforme XVI 7
dumosum XVI 6
dupinianum XVI 7
ecuadoriale XVI 6
ecuadorialis XVI 6
edule XVI 6
elongatum XIII 160, XVI 8, XVI 36
eos XVI 6
erinaceum XVI 38
exiguum commutata XVI 8
festivum XVI 7
fimbriatum XVI 38
flavum XVI 6
formosum XVI 7
fragile XVI 38
fragum XIII 172, XVI 6
gabbi XVI 43
glebosum XVIII 38
globosum XVIII 38
graniferum XIII 177
granulosum XVI 8
gratiosum XVI 38
groenlandicum XVI 8
haitense XIII 177
hatchetigbeense XVI 8
haueri XVI 41
heredium XIII 177
hiculum XVI 38
hillanum XVI 8
hornelli XIII 164
hudsonense XVI 38
hungaricum XVI 41
hystrix XVI 6
inconspicuum XIII 154
indicum XVI 38
isocardia XIII 154, XVI 8, XVII 55, XVIII 37
kansasense XVI 8
leucostomum XIII 161
lyratum XVI 7
maculatum XIII 164
maculosum XIII 164
mageri XVI 41
magnuum XIII 161, XVI 6
mauritianum XVI 38
medium XIII 184, XVI 5
mellisum XVI 7
multicostatum XVI 6
notabile XVI 8
nuttallii XVI 6
oblongum XIII 184, XVI 7
obovale XVI 5
panamense XVI 40
papillosum XVI 8
parvum XVI 8
patulum XVI 8
paucicostatum XVI 8
pauperculum XVI 6
peramabile XVI 7
peramabilis XVI 7
peruviana XVI 8
philippinense XVI 38
pluriradiatum XVI 8
porulosum XVI 7
procerum XVI 7
productum XVI 38
propebanneianum XVI 8
propeciliare XIII 152
quadrigenarium XVI 6
radula XVI 38
rectispina XVIII 43
retusum XVI 7
ringens XVI 6
robustum XIII 185
rugiferum XVI 7
samarangae XVI 7
schmidti XVI 41
semiasperum XVI 7
serrulatum XVI 38
smidti XVI 41
soleniforme XIII 164, XVI 8
sorrentoensis XVIII 43
spatiosum XVI 7
speciosum XVI 6

sphaeroideum XVI 7
spillmani XVI 8
spinosum XVI 38
subquadratum XVI 7
tenuisulcatum XVI 7
thetidis XVI 8
tuberculatum XVI 8
tumidum XVI 40
ventricosa XIII 185
virginianum XVI 8
vulva XVI 40
waitakiense XVI 7
whitei XVI 6
Cardium (Acanthocardia)
acrocome XIII 153, XVIII 40
dissidepictum XIII 153, XVIII 42
propeciliare XIII 152
Cardium (Bucardium) XVI 16
ringens XVI 14, XVI 18
Cardium (Cardium) XVI 16
Cardium (Cerastoderma)
alumen XIII 186
chipolanum XIII 185
lavrani XVI 38
phlyctaena XIII 152
Cardium (Cerastoderma, Acanthocardia)
spinosum XVI 38
Cardium (Cerastoderma, Parvicardium)
iranjanense XVI 38
Cardium (Dinocardium) ecuadorialis XIII 185
Cardium (Fragum)
burnsii XIII 181
callopleurum XIII 177
elattocostatum XIII 181
gatunense XVII 56
Cardium (Laevicardium) compressum XIII 185
Cardium (Orthocardium) XVI 16
porulosum XVI 18
Cardium (Papyridea)
bulbosum XIII 165
hiatus XIII 165
spinosum XIII 165
Cardium (Trachycardium)
cestum XIII 157
cinderellae XVIII 42
cinderellae alternatus XVIII 42
claibornense XIII 153, XVIII 38
delphicum ballastrum XIII 158
gatunense XVII 56
globosum XVIII 38
inconspicuum XIII 162
linguatigris XIII 164
parile XIII 156
pessoae XVIII 42
pristipleura XIII 164
propeciliare XIII 152
virile XIII 154
waylandi XIII 164
Cardium (Trigoniocardium)
alicula XIII 172
berberum XIII 172
simrothi XIII 180
carduus, Acanthotrophon XIV 132
carduus, Attiliosa XII 118
carduus, Murex XII 118
caribaeus, Lithophagus XIX 169
caribbaea, Tritonalia XIX 70, XIX 77
caribbaea, Tritonalia (Ocinebrina) XIX 77
caribbaeus, Muricopsis (Risomurex) XIX 70, XIX 77
caribbaeus, Risomurex XIX 77
caribbeana, Weisbordella XVIII 130
caribbeanica, Gephyrocapsa XI 80, XI 119, XV 13, XV 28, XVI 146, XIX 131
Caribiella XI 122, XIX 63
Caribosiren turneri XIV 161
carica sp. cf., Busycon XIX 108
Caricella isabellae XIV 115
carinata, Asterigerina XI 288, XI 294, XI 296
carinata, Bairdoppilata XIV 137
carinata, Biloculina XI 275
carinata, Pyrgo XI 275, XI 284, XVI 92
carinata, Triloculina XI 275
carinatus, Peneroplis XI 277, XI 288
Carmione XVI 107
CARNATOLINTRA, AMPLECTODUCTINA *XIX 189,* **XIX 190**
carnicolor, Poirieria (Panamurex) XII 103
carolinensis, Eutrephoceras XII 238, XII 240
carolinum, Cardium XVI 7
carolinum, Granocardium (Granocardium) XVI 16
carolinensis, Lyria XIV 113
carolinensis, Lyria (Harpeola) XIV 113, XIV 118
caronis, Nerita XVII 132
carpenterii, Quercus XIII 60
Carpocanarium XX 20
CARPOCANIIDAE *XX 20*
Carpocanistrum XX 20
carterae, Cricosphaera XI 12, XI 179
carteri, Coccolithus XV 13
carteri, Helicosphaera XV 13
Carya XVII 29
CASSIDAE *XVII 101*
Cassidaria mutica XIX 178
Cassidulina XI 296, XIX 182
subglobosa XI 298, XVI 94
CASSIDULINACEA *XI 296*
CASSIDULINIDAE *XI 296*
Cassidulinoides mexicana XVI 94
CASSIDULOIDA *XVIII 130*
Cassidulus XVIII 133
conradi XVIII 138
ericsoni XVIII 138
globosus XVIII 138
trojanus XVIII 138
Cassis XI 96
spp. XVIII 131
cassis, Nodobaculariella XI 273, XVI 92
cassis, Vertebralina XI 273
Casteroides XVII 72
castleberryensis, Cytherelloidea XII 93
castleberryensis aff., Cytherelloidea XII 93, XII 97
Casuarinidites
granilabratus aff. XVII 29

sp. XVII 36
cataphratus, Murex XIX 86
CATAPSYDRACIDAE *XIV 56*
Cativella XVI 86, XIX 155
navis XIX 138
pulleyi XIX 155
semitranslucens aff. XIX 155
caucasica, Reticulofenestra XI 28, XI 29, XI 197, XI 198
caudata, Ambocythere XIX 138
CAUDATUM, *Inversidinium* **XII 218,** *XII 222*
caudatum, Palaeotetradinium XVII 37
caudigera, Oolina XVI 92
caudigerus, Lithodomus XIX 170
Caudites
nipeensis XIX 138
rectangularis XIX 138
cava, Ericsonia XIX 18
cavernosa, Montastrea XIII 116
cavus, Coccolithus XIX 18
cavus var. a., Coccolithus XIX 19
cavus var. a cf., Coccolithus XIX 18, XIX 20
cayenensis, Diodora XVII 100, XIX 61
cellulosa, Favartia XVI 47
cellulosum, Palmoxylon XV 59
Celtis sp. XVII 85, XVIII 89, XVIII 90
centralis, Globorotalia (Turborotalia) XII 148
centrocarpum, Baltisphaeridium XII 189
centrocarpum, Hystrichosphaeridium XII 189
centrocarpum, Operculodinium XII 189, XII 206
centrota, Cancellaria XII 35
cepacea, Cheilea XI 170
Cepekiella XI 236
elongata XI 236
hayi XI 236
lumina XI 208, XI 236
lumina cf. XVII 31
CEPHALOPODA *XVI 56, XVI 61*
Cephaloraphidites XVI 125
CEPHALORAPHIDITIDAE *XVI 125*
Cerastes XVI 6
Cerastoderma XIII 185, XVI 6
chipolanum XIII 185
edule XVI 36, XVI 38
kiktenkoi XVI 7
Cerastoderma (Cerastoderma) XVI 22
Cerastoderma (Korobkoviella) XVI 22
Ceratiopsis diebelii XII 192
Ceratobulimina (Ceratocancris) stellata XI 181
CERATOBULIMINIDAE *XI 300*
Ceratolithus
ACUTUS XI 115, *XI 116, XVIII 33*
amplificatus XI 115, XI 116
cristatus XI 118, XV 13, XV 24
dentatus XI 116
primus XI 118, XVIII 35
rugosus XI 115, XI 120, XVIII 29
tricorniculatus XI 118, XI 120
cerina, Gouldia XVIII 124
cerina, Gouldia (Gouldia) XVIII 123
CERITHIDAE *XVII 100*
Cerithium XIX 83
atratum XIX 61
ocalanum XII 137
Cernina XI 100
cervicornis, Acropora XIII 122
Cestodiscus XX 43
maculatus XX 43, XX 48
pulchellus XX 43
cestum, Cardium (Trachycardium) XIII 157
cestum, Trachycardium (Conilocardium) XIII 150, XIII 157, XIII 158, XIII 178, XVI 22, XVI 28
cetoides, Zeuglodon XV 57
Chaetoceros XX 43
cinctus XX 43, XX 48
diadema XX 43, XX 48
dicladia XX 43, XX 48
sp. XX 43, XX 50
CHALLENGERIIDAE *XX 34*
Challengeron XX 34
diodon XX 32, XX 34
Chama congregata XVII 103, XIX 61
Chamelea mississippiensis XVIII 75
CHAMIDAE *XVII 103*
chaperi, Lepidocyclina XII 141
Chara XIX 142
Chatangiella sp. XVII 28
Chathalmus XIX 55
checchiai, Dimya XV 50
Cheilea XI 170
bernayi XI 170
boutillieri XI 170
cepacea XI 170
dryas XI 170
equestris XI 168, XI 171
stella XI 170
uncinata XI 168, XI 171
Chelodes XVI 65
cheloma, Braarudosphaera XI 188, XI 212
chemardensis cf., Holkopollenites XVII 36
chemardensis, Holkopollenites XVII 39
Chenopodipollis spp. XVII 39
chiapasensis, Lyrischapa XV 120, XV 122
chiapasensis, Volutocristata XV 118
Chiasmolithus XI 15, XI 193, XIX 22
bidens XI 15, XI 16, XI 22, XI 194, XIX 8
californicus XIX 22, XIX 26
consuetus XI 15, XI 16, XI 22, XVII 31, XIX 24, XIX 26
danicus XI 15, XIX 8
delus XI 193
expansus XI 16, XI 18, XI 193
gigas XI 18, XI 19, XI 22
grandis XI 19, XI 26, XI 193, XI 224
oamaruensis XI 15, XI 19, XI 22, XIX 22
solitus XI 16, XI 20, XI 193, XI 226
staurion XI 195
titus XI 18, XI 20, XI 194, XI 226
chiastus, Zygolithus XIX 30
Chicoreus [see also Murex (Chicoreus)]
dujardinoides XI 83, XV 108, XV 112
floridanus XI 86
florifer XI 90
lepidotus XII 17
Chicoreus (Chicoreus)

argo XI 90
brevifrons XI 84
BULLISI XI 91, *XI 92*
cornurectus XI 84
dilectus XI 87
dilectus var. XI 87, XI 88
ELUSIVUS XI 82, *XI 84*
MERGUS XI 91, *XI 92*
PROLIXUS XI 88
spectrum XI 90, XI 92
XESTOS XI 86, *XI 88*
Chicoreus (Naquetia) XVI 47
Chicoreus (Phyllonotus) XI 82
childrenae, Lucina XVII 135
chilensis, Xestoleberis XIX 156
Chilostomella mexicana XV 6
Chione XII 143, XVIII 73
cancellata XVII 104
intapurpurea XVII 104, XIX 61
ulocyma XVI 97
Chione (Chione)
bainbridgensis XVIII 74
craspedonia XVIII 73, XVIII 74
perbrevisformis XVIII 75
Chiphragmalithus XI 70
alatus XI 11
calathus XI 66, XI 70
dubius XI 70, XI 238
quadratus XI 9
protenus XIX 32
chipolana, Antillophyllia XIII 70, XIX 172
chipolana, Neritina XVI 159
CHIPOLANA, *Nucinella* **XVIII 161,** *XVIII 162*
CHIPOLANA, *Panopea* **XVIII 166,** *XVIII 167*
chipolana, Smaragdia XVI 159
chipolana, Turbinella XVIII 50
chipolanum, Cardium (Cerastoderma) XIII 185
chipolanum, Cerastoderma XIII 185
chipolanum, Crucibulum XI 168
chipolanum, Dinocardium XIII 174, XIII 178, XIII 185
chipolanum, Dinocardium (Exocardium) XIII 185
chipolanus, Conus XII 6, XII 10, XII 32
Chiton tuberculatus XVI 70
Chlamys (Aequipecten) flintensis XII 143
Chlamys (Lyropecten) incertae XII 141, XVIII 73
Chloromya XIX 160
Choanopollenites
alabamicus XVII 39
consanguineus XVII 39
conspicuus XVII 39
conspicuus cf. XVII 36
discipulus XVII 39
sp. XVII 36
transitus XVII 36
choctawhatcheensis, Cytheretta XIX 139
choctawhatcheensis, Paracypris XII 59
choctawhatcheensis sp. cf., Paracypris XIX 139
choctawhateensis, Microcytherura XIX 139
cholnokyi, Actinocyclus XX 40, XX 44
chondrum, Ctenidodinium XVIII 150
Chonetinella XIX 115
CHORISTIDA *XVI 125*
CHORDATA *XV 102*
Chrysalidinella popei XVI 94
Chrysalogonium XIV 82
Chrysophyllum brevisulcatum XVII 28
CHRYSOPHYTINA *XIX 18*
cibaoensis, Lenticulina XIV 94
CIBICIDIDAE *XI 294*
Cibicides XI 294, XIV 103
alleni XVII 35
americanus XV 5
deprimus XI 294
filisolaensis XV 6
floridana XI 294, XI 298
floridanus XI 88, XVI 92
howelli XVII 35
neelyi cf. XVII 35
praecursorius XVII 35
refulgens XI 294
sp. XI 294, XVII 35
CIBICIDINAE XI 294
Cibicidoides io XVI 94
Ciliatocardium XVI 6
ciliatum, Cardium XVI 6
ciliatum, Clinocardium (Ciliatocardium) XVI 38
ciliatum, Corculum (Keenocardium) XVI 38
cimitariopsis, Gastrochaena XII 161
cimitariopsis, Gastrochaena (Spenglaria) XII 161
cinctus, Chaetoceros XX 43, XX 48
cinderellae, Agnocardia XVIII 42
cinderellae, Cardium (Trachycardium) XVIII 42
cinderellae alternatus Cardium (Trachycardium) XVIII 42
cingulatum, Nemocardium XVI 34
cinnamomea, Modiola XIX 172
cinnamomeus, Modiolus XIX 172
cinnamomeus, Modiolus (Botula) XIX 172
cira, Mytilopsis XVIII 164
Circe amica XVIII 124
CIRCINAE *XVIII 123*
Circodiscus XX 13
microporus XX 13, XX 14
circularis, Miliolinella XI 276, XI 286
circularis, Porodiscus XX 16
circularis, Triloculina XI 276
circularis, Xiphospira XX 16
circularis sp. cf., Xiphospira XX 16, XX 18
Circulodinium deflandrei XII 208
circulus, Dictyocha (Mesocena) XX 94
circulus, Mesocena XX 94, XX 100
circulus sp. cf., Mesocena XX 94, XX 100
circumstriatus, Aesculiidites XVII 39
circumtexta, Peripyramis XX 20
CIRRIPEDIA *XVI 98*
Cirsotrema togatum XVI 155, XVI 156
citrinus, Mytilus XIX 161
citrusensis, Falsilyria XIV 122
citrusensis, Lyria XIV 122
Cittarium pica XIII 114
Cladogramma XX 43
californicum XX 43, XX 50
dubium XX 43, XX 50

Cladopyxidium XII 177
Claenodon ferox XV 78
claiboplata, Venericardia XV 71
claibornense, Agnocardia XVI 5
claibornense, Cardium (Trachycardium) XIII 153, XVIII 38
claibornensis, Lamarckina XI 8
claibornensis, Siphonina XI 6
claiborniana, Quinqueloculina XI 6
claricristata, Ephedra XVII 29
clarksvillensis, Poirieria (Panamurex) XI 152, XII 103
Classopollis sp. XVII 39
clathrata, Distorsio XVII 101
Clathrolithus ellipticus XIX 9
clathrata b, Cornutella XX 22
Clathrocyclas XX 22
cabrilloensis XX 22
Clavelloides XIX 190
claviformis, Isthmolithus XI 244
claviger, Rhabdosphaera XI 44, XI 230
clavigera, Melosira XX 52, XX 56
clavigera, Rhabdosphaera XVI 87
Clavulina XI 272
angularis difformis XI 272
difformis XI 272
tricarinata XI 272
Clavulinoides midwayensis XVII 35
clavum, Spinidinium XII 196, XII 218
claybornensis, Jefitchia XV 100, XV 103
Clementia (Egesta) grayi XI 101
cleryi, Typhis XVII 128
clevei, Actinoptychus XX 41, XX 46
clevei, Agassizia XVIII 132
clinata, Dictyocha XX 85, XX 88
Clinocardium XVI 6
buelowi XVI 38
uchida XVI 38
Clinocardium (Ciliatocardium) XVI 22
ciliatum XVI 38
Clinocardium (Clinocardium) XVI 22
nuttallii XVI 28, XVI 36, XVI 38
Clinocardium (Fuscocardium) XVI 22
braunsi XVI 38
Clinocardium (Keenocardium) XVI 22
californiense XVI 28
Clinocardium (Planicardium) XVI 22
virginianum XVI 38
Clinorhabdus turriseiffeli XIX 34
Clisiphontes XIV 88
Clisophontes XIV 88
Clithrocytheridea sp. XVII 34
clivosa, Diplorai XIII 118
Closteria XIII 61
Clypeaster subdepressus XIII 126
CLYPEASTEROIDA *XVIII 130*
coarctata, Gregriella XIX 169
Coccolithus XI 13, XI 194, XIX 19
bidens XI 15
bisectus XI 197
bisulcus XIX 36
californicus XIX 22
carteri XV 13
cavus XIX 18
cavus var. A XIX 19
cavux var. A cf. XIX 18, XIX 20
coenurus XI 28, XI 198
consuetus XI 15, XI 20, XI 194, XIX 24
crassipons XI 194, XI 242
crassus XIX 20
crassus var. A XIX 20
crassus var. B XIX 20
cretaceus XI 19, XI 193
delus XI 21, XI 193
diaphragma XI 195
doronocoides XI 119, XV 13, XV 24
eminens XI 21
eopelagicus XI 13, XI 16, XI 24, XI 25
expansus XI 18
gigas XI 19
gigas aff. XIX 22
grandis XI 19, XI 193
helis XIX 26
leptoporus XV 14
lusitanicus XI 24, XI 195
muiri XI 25
oamaruensis XI 19
oceanicus XI 13, XI 194, XIX 19
ORBICULATUS XIX 20, *XIX 32*
orbiculatus cf. XIX 22, XIX 32
pelagicus XI 13, XI 14, XI 16, XI 22, XI 119, XI 194, XV 14, XV 26, XVII 31
pelicomorphus XI 198
pelycomorphus XI 29
placomorphus XI 198
pseudocarteri XI 197
pseudoumbilicatus XV 16
sarsiae XI 14, XI 16, XI 22, XI 194, XI 228
solitus XI 20, XI 194
sp. XI 15, XIX 18, XIX 22, XIX 42
sp. A XI 194, XI 242
staurion XI 22, XI 194, XI 195
stavensis XI 197
umbilicus XI 29, XI 198
COCCOLITHACEAE *XI 12, XI 192, XIX 18*
Coccolithites
annulus XV 13
dela XI 21, XI 193
COCCOLITHOIDEAE *XIX 18*
Coccolithophora cretacea XIX 36
COCCOLITHOPHYCEAE *XIX 18*
COCCOLITHOPHYCIDAE *XIX 18*
Cocconeis XX 43
costata XX 43, XX 50
decipiens XX 43, XX 50
disrupta XX 43
triumphis XX 43, XX 50
Coccosphaera
leptopora XV 14
leptoporas XI 195
pelagica XI 14, XV 14
Cochlea nebulosa XIII 160, XVI 8
cockfieldensis, Gothanipollis XVII 29
cocoaensis, Planulina XII 148
cocoaensis, Robulus XIV 85
Codonia campanulata XII 183

Codoniella XII 183
coenura, Reticulofenestra XI 26, XI 28
coenurus, Coccolithus XI 28, XI 198
cofacorys, Jaspidella XVI 116, XVI 119
cofacorys, Olivella XVI 119
cognatus, Fusus XIII 196
colei, Dentalina XVII 35
colinensis, Turbinella XVIII 47
colinensis, Xancus XVIII 52
colligerum, Baltisphaeridium XII 184
colligerum, Diphyes XII 184, XII 200
colligerum, Hystrichosphaeridium XII 184
collumnosa, Quinqueloculina XI 274
Colonammina XVIII 158
Colpophyllia sp. XIII 118
colporatus, Osculapollis XVII 39
Colubraria XI 97
columba, Trigoniocardia (Americardia) XIII 166, XIII 178
COLUMBELLIDAE *XVII 101*
comata, Biloculina XI 275
comata, Pyrgo XI 275
comatus, Nautilus (Orthoceras) XIX 191
combazii, Ctenidodinium XVIII 148
combazii cf., Ctenidodinium XVIII 150
comis, Triloculina XI 276
communis, Dentalina XVI 92
communis, Ficus XVII 101
comutatum, Parvicardium XVI 14
compacta, Helicosphaera XI 212
compacta, Helicopontosphaera XI 11, XI 212, XI 234
compacta, Quadracythere XIX 139
complanata, Millepora XIII 130
compressa, Bulimina XI 290
compressa, Cyclorbulina XI 278
compressa, Fursenkoina XI 296, XI 298
compressa, Globorotalia XII 176, XVII 35, XIX 11
compressa, Orbiculina XI 278
compressa, Virgulina XI 296
compressum, Cardium (Laevicardium) XIII 185
compressum, Laevicardium XIII 174, XIII 178, XIII 185
compressus, Archaias XI 278
complexa, Dictyocha XX 86, XX 88
compta, Quinqueloculina XVI 92
Comptonia XVII 28
CONACEA *XII 3*
Conarachnium martini XX 22
concavata, Terebra XVII 102
concavus proteus, Balanus XVI 97
concentrica, Ervilia XVII 103
concentrica, Hanzawaia XVI 92
concentrica, Nuculana XVII 102
concentrica, Stomatorbina XVI 92
concentricus, Aulacodiscus XX 42, XX 46
concentricus, Tripodiscus XX 42
CONCHIFERA *XVI 67*
Concholepas drezi XVI 159
conchyliophorus, Trochus XI 164
concinnus, Heliorthus XIX 30, XIX 40
concinnus, Micrantholithus XI 188
concinnus, Neochiastozygus XVII 31
concinnus, Zygolithus XIX 30
CONCORALLA, *Petricola* (Petricoxenica) **XII 47,** *XII 48, XII 163*
condecorum, Triceratium XX 64, XX 66
confossa, Discolithina XI 30, XI 208
confossus, Discolithus XI 30, XI 208
confragosa, Hemicythere XIV 144
confragosa, Radimella XIV 144, XIV 150, XIX 139
confusus, Paraalnipollenites XVII 38
Conger XV 99
dissimilis XV 100, XV 102
vetustus XV 100, XV 102
conglobata, Globigerina XIV 40, XV 11, XVIII 34
conglobata, Trochammina XVIII 20
Conglobatoides XVIII 20
conglobatus, Globigerinoides XVI 21, XIV 40, XIV 46, XVI 94
conglobatus conglobatus, Globigerina XVIII 22
conglobatus conglobatus, Globigerinoides XV 11, XV 16, XVI 145, XVIII 34
conglomerata, Globoquadrina XV 11, XV 18
Conglophragmium XVIII 20
congregata, Chama XVII 103, XIX 61
CONGRIDAE *XV 102*
CONIDAE *XII 3*
CONILOCARDIUM XIII 157
CONINAE *XII 3*
conjugens, Cardium XVI 41
conomiozea, Globorotalia XV 11
Conosphaeridium XII 181
striatoconus XII 181
striatoconus cf. XII 181, XII 198
conradi, Aurila XIX 134
conradi, Cassidulus XVIII 138
conradi, Malzella XIX 139
conradi, Muricidea XII 109
conradi californica, Aurila XIV 144
conradi floridana, Aurila XII 69, XIV 143
conradi littorala, Aurila XII 69
conradiana, Cancellaria XII 34
consanguineus, Choanopollenites XVII 39
consobrinus, Conus XII 20
consors, Trachycardium (Trachycardium) XVI 28
conspicua, Stenoplax XVI 66
conspicuus, Choanopollenites XVII 39
conspicuus cf., Choanopollenites XVII 36
conspicuus, Parsonsidites XVII 27
constantii, Venericardia XVI 41
constricta, Auliscus XX 42, XX 48
constricta, Macoma XVII 103
constrictum, Crucibulum (Dispotaea) XI 168
consuetus, Chiasmolithus XI 15, XI 16, XI 22, XVII 31, XIX 24, XIX 26
consuetus, Coccolithus XI 15, XI 20, XI 194, XIX 24
continuum, Ctenidodinium XVIII 150
contorta, Lucina XVII 135
contortus, Marthasterites XIX 9
contracta, Corbula XVII 104, XIX 108
contracta, Symplocos XVII 28
Conus XII 3, XV 48, XV 110

adversarius XVI 97
AMBONOS XII 13, *XII 14*
ANEUROS XII 10, *XII 14*
anodosus XII 26
AQUOREUS XII 17, *XII 22*
atractus XII 25
chipolanus XII 6, XII 10, XII 32
consobrinus XII 20
corrugatus XII 12
CRACENS XII 14, *XII 18*
cruziensis XII 32
delessertii XIX 61
demiurgus XII 7, XII 10
dodona XII 22, XII 24
draperi XII 21
DREZI XII 24, *XII 26*
ERUGATUS XII 17, *XII 18*
fergusoni XII 9
floridanus XII 7
fusiformis XII 25
GARDNERAE XII 12, *XII 14*
granulatus XII 32
INFULATUS *XII 26,* **XII 28**
isomitratus XII 8, XII 10
isomitratus sulculus XII 8
jaspedius XII 7
jaspedius stearnsi XIX 61
marmoreus XII 3
marylandicus XII 7
molis XII 21
multiliratus XII 28
nemorideditus XII 22
patricius XII 18
PRAECIPUUS XII 20, *XII 22*
princeps XII 28
RAPUNCULUS XII 21, *XII 22*
sauridens XII 16
SEXTONI XII 31
sp. XIII 122, XVI 97
spurius XII 22
stenostoma XII 16
stimpsoni XII 24
submoniliformis XII 25, XII 26
sulculus XII 8, XII 10
TAPETUS XII 6, *XII 18*
trajectionis XII 13
TRICORATUS XII 20, *XII 22*
turbinopsis XII 28
vegrandis XII 18, XII 22
viteus XII 25, XII 26
waltonensis XII 26
waltonensis anodosus XII 26
convexa, Thalassiosira XX 62
convexum, Agnocardia XVIII 37
convexum, Cardium XVIII 37
cookanum, Eutrephoceras XII 238, XII 240
COOKEI, *Dermomurex (Takia)* **XI 149,** *XI 150*
cookei, Glycymeris XVIII 73
cookei, Lithophaga XIX 171
cooksoniae, Isabelidinium XVII 43
cooksonii, Deflandrea XII 191, XII 210
cooperi, Preacanthochiton XVI 67
cooperi, Riddellia XIII 61
Cor XVI 6
corallinum, Lycopodium XIII 61
coralliophaga, Gregariella XIX 169
Coralliophila
incompta XII 111, XII 134
nodulosa XII 133
philippiana XII 111, XII 120
coralliotis, Dimya XV 50
Corbula XV 39
contracta XVII 104, XIX 108
oniscus XV 56
quadrata XVI 160
swiftiana XVII 104
corbula, Phormostichoartus XX 30, XX 32
CORBULIDAE *XVI 160, XVII 104*
corbuloidea, Anisodonta XVI 162
corbuloides, Basterotia XVI 160
Corculum XVI 6, XVI 20
cardissa XVI 22, XVI 24
Corculum (Keenocardium)
californiense XVI 40
ciliatum XVI 38
Corculum (Trigoniocardia) auri XVI 36
cordata, Stachys XIII 26
cordatum, Echinocardium XVIII 134
Cordissa XVI 6
Cordium XVI 6
Cordosphaeridium XII 182
bipolare XII 188
fimbrospinosum XII 182, XII 198
gracile XVII 30
inodes XVII 37
multispinosum XVII 37
cornigerium, Lithodesmium XX 52, XX 56
cornudensis, Voorthuyseniella XII 155
cornudensis cruciformis, Voorthuyseniella XII 155, XIII 138
cornula americana, Pterygocythereis XII 85
Cornulina XVI 150
armigera XVI 150
minax XVI 150
minax compressa XVI 150
cornurectus, Chicoreus (Chicoreus) XI 84
Cornuspira planorbis XI 273
cornuspira, Stylodicta XX 16
cornuta, Arcinella XVII 103, XIX 61
cornuta, Cyrtocapsa (Cyrtocapsella) XX 22
cornuta, Cyrtocapsella XX 22
Cornutella XX 22
clathrata B XX 22
paloverdensis XX 22
profunda XX 22
cornutus, Murex (Bolinus) XI 153
cornutus, Spiniferites XII 189, XVII 37
cornutus cf., Spiniferites XII 189, XII 208
corona, Melongena XVI 149, XVII 101
coronata, Distephanus XX 92, XX 94
coronata, Melosira XX 52, XX 56
Coronifera XII 182
oceanica XII 182, XII 198
corrugata, Dimya XV 38
corrugata, Modiola XIX 169
corrugatus, Conus XII 12

corticaria, Oliva XVI 107
Corvina XV 99
intermedia XV 100, XV 103
coryloides, Momipites XVII 29
Coscinodiscus XX 43
antiquus XX 43, XX 50
asteromphalus XX 44, XX 50
biradiatus XX 44, XX 50
borealis XX 46, XX 52
decipiens XX 64
egregius XX 46, XX 54
excentricus XX 43
hirosakiensis XX 44, XX 50
hyalinus XX 64
incretus XX 46, XX 54
janischii XX 44
kurzii XX 44, XX 50
laesareolatus XX 44, XX 50
marginatus XX 44, XX 52
monicae XX 44, XX 52
nitidus XX 44, XX 52
nodulifer XX 44, XX 52
obscurus XX 44, XX 52
oculusiridis XX 46, XX 52
pilosus XX 46, XX 52
plicatus XX 46, XX 52
praepaleacea XX 58
radiatus XX 46, XX 54
robustus XX 46
stellaris XX 46
subtilis XX 46, XX 54
symbolophora XX 46, XX 54
tabularis XX 46
vetustissimus XX 46, XX 54
Coscinopora XVI 142
Coscinosira oestrupii XX 64
costaria, Calyptraea XI 165
costaria, Calyptraea (Trochita) XI 164, XI 165, XI 166
costata, Calocycletta XX 6
costata, Cancellaria XII 40
costata, Cocconeis XX 43, XX 50
costata, Cyrtopleura XVII 104
costata, Exogyra XII 178
costata, Lyria XIV 109
costata, Odontachitina XVII 28
costata, Petricola XII 47, XII 163
costata, Siphogenerina XI 284, XI 292
costata, Voluta XIV 113
costatum, Cardium XVI 6, XVI 14, XVI 18
costatus, Dimyodon XV 51
costatus, Rhabdolithus XI 71, XI 244
cottaldina, Venericardia XVI 41
cotteavi, Dermomurex XI 127
cotteavi, Murex XI 149
couvrili, Laevicardium (Trachycardium) XVI 36
crabro, Diploneis XX 48, XX 54
crabro, Pinnularia XX 48
CRACENS, *Conus* **XII 14,** *XII 18*
craspedonia, Chione (Chione) XVIII 73, XVIII 74
crassacrotonensis, Globorotalia XV 11
crassacrotonensis, Globorotalia (Turborotalia) XV 11, XV 22
crassaformis, Globigerina XVIII 34
crassaformis, Globorotalia XVI 86, XVIII 34
crassaformis, Globorotalia (Truncorotalia) XVIII 34
CRASSATELLIDAE *XVII 103*
crassicosta, Jania XIX 84
crassicosta, Janiopsis XIX 84
crassicosta, Muricopsis XIX 84
crassicosta, Muricopsis (Risomurex) XIX 72, XIX 84
crassiformis, Globigerina XIV 60
crassiformis, Globorotalia XIV 29, XIV 60, XIV 70
crassiformis, Globorotalia (Truncorotalia) XVIII 24
Crassilabrum XIII 194
crassiliratus, Murex XI 129
Crassina XVI 165
danmoniensis XVI 165
Crassinella lunulata XVII 103
crassipons, Coccolithus XI 194, XI 242
Crassostrea virginica XVII 103, XVII 112, XIX 61
crassula conomiozea, Globorotalia (Globorotalia) XV 11, XV 20
crassus, Coccolithus XIX 20
crassus var. A, Coccolithus XIX 20
crassus var. B, Coccolithus XIX 20
crassus, Discolithus XI 30
crassus, Zygrhablithus XI 244
craticulus, Toweius XIX 38
CRAURA, *Perna* **XIX 160,** *XIX 162*
crearoi, Dimya XV 50
creber, Blackites XI 38, XI 41, XI 200, XI 224
creber, Rhabdolithes XI 41, XI 224
creber, Rhabdolithus XI 41, XI 224
crebra, Rhabdosphaera XI 41, XI 224
crenalirata, Astarte XVI 42
crenata, Calyptraea XI 165
crenata, Calyptraea (Trochita) XI 165, XI 166
crenata, Harpa XVIII 54, XVIII 58, XVIII 59
crenata cf., Harpa XVIII 59
crenata, Postligata XVIII 68
Crenella XIX 164
divaricata XIX 164
miniscula XIX 162, XIX 164
Crenella (Modiolaria) translucida XIX 166
CRENELLINAE *XIX 164*
crenifer, Vitularia XIII 192
creola, Myripristis XV 100, XV 103
crenulata, Pyramidella XVII 102
Crepidolithus ocellatus XI 34
Crepidula XI 166
dilatata XI 166
dorsata XI 166
foliacea XI 166
fornicata XVII 101, XIX 61
plana XVII 101
sp. XIX 108
strigata XI 166
Crepidula (Crepipatella) insculpta XI 168
Crepidula (Janacus) gibbosa XI 166
Crepipatella [see also Crepidula (Crepipatella)]

XI 166
apprimus XI 168
dilatata XI 170
dorsata XI 170
Creseis acicula XVII 102
Cresswellia turris XX 60
cretacea, Coccolithophora XIX 36
cretacea, Plicatopollis XVII 36
cretacea, Prediscosphaera XIX 34, XIX 36
cretaceus, Coccolithus XI 19, XI 193
cretaceus, Deflandrius XIX 36
cretaceus, Discolithus XIX 36
cribraria, Discolithina XI 206, XI 238
Creusia neogenica XVI 97
cribellatus, Margocolporites XVII 39
cribraria, Pontosphaera XI 206
Cribratina XIV 83
Cribrobigenerina XIV 83
Cribrocentrum reticulatum XI 195
Cribroelphidium XI 292
kugleri XI 292, XI 298
poeyanum XI 292, XI 298
Cribrogloborotalia XII 143, XVIII 73
Cribrohantkenina XIV 83
CRIBROLENTICULINA XIV 90
AKERSI XIV 90, *XIV 94, XIV 96, XIV 98, XIV 100*
Cribroperidinium XVIII 148
orthoceras XII 186
Cribropyrgo XIV 83
Cribrorobulina XIV 82
serpens XIV 83
taustoma XIV 83
Cribrosphaera ehrenbergi XIX 42
Cribrosphaerella XIX 42
ehrenbergii XIX 34, XIX 42
sp. XI 208
Cribrospirolina XIV 83
Cribrospongia XVI 138
CRIBROSPONGIIDAE *XVI 138*
Cribrostomoides XIV 84
Cricolithus jonesi XVI 87
Cricosphaera carterae XI 12, XI 179
cricota, Umbilicosphera XV 13
Criocardium XVI 6
crisiae, Dictyophimus XX 22
cristagalli, Mytilus XIII 190
Cristallolithus XI 80
macroporus XV 14, XV 26
multiporus XV 14, XV 26
cristata, Globigerina XVIII 35
cristata, Tellidora XVII 103
cristataus, Ceratolithus XI 118, XV 13, XV 26
cristatus, Murex XIX 85
cristatus, Muricopsis XIX 86
Cristellaria
gemmata XIV 94
granosa XIV 94
mexicana XIV 94
rotulata XV 5
vaughani XIV 94, XV 5
Cristellariopsis XIV 88
cristi, Lenticulina (Robulus) XIV 94
cristobalensis, Lenticulina XIV 94
Cromydruppocarpus XX 13
esterae XX 13, XX 14
Cronia XII 134
crosseanum, Dolium XIX 178
crosseanum, Eudolium XIX 178
crosskeiana, Bairdia XIV 139
Crucibulum XI 165
chipolanum XI 168
Crucibulum (Dispotaea) constrictum XI 168
cruciformis, Voorthuyseniella XII 155, XIII 138
Crucilithus XI 20
Cruciloculina XIV 183
Cruciplacolithus XI 20, XI 195
delus XI 21, XI 22, XI 26, XI 193
eminens XI 21, XI 22
staurion XI 21, XI 26, XI 195, XI 238
tenuiformis XI 22, XI 28, XI 32
tenuis XI 20, XVII 31, XIX 24
tenuis var. A XIX 24, XIX 38
tenuis var. B XIX 24, XIX 38
tenuis var. C XIX 26, XIX 38
crux, Cyathosphaera XI 21, XI 193
crux, Dictyocha XX 90
crux, Distephanus XX 90
cruzianus, Conus XII 32
Cryptocardia XVI 6
bajocensis XVI 6, XVI 32
CRYPTODONTA *XVII 48*
CRYSTALLOLITHACEAE *XI 80*
Crystallolithus XI 80, XI 182
Ctenidodinium XVIII 150
chondrum XVIII 150
combazii XVIII 148
combazii cf. XVIII 150
continuum XVIII 150
elegantulum XVIII 150
ornatum XVIII 150
sellwoodii XVIII 150
tenellum XVIII 150
?Ctenidodinium
mosaicum XVIII 152
rotundum XVIII 152
schizoblatum XVIII 152
scissum XVIII 152
stauromatos XVIII 152
Ctenocardia XVI 6
Ctenocardia (Afrocardium) XVI 20
exocha XVI 24
Ctenocardia (Ctenocardia) XVI 20
symbolica XVI 24
symbolica cf. XVI 24
Ctenocardia (Microfragum) XVI 20
festiva XVI 22
cubae, Weisbordella XVIII 130
cubensis, Krithe XII 61
Cubitostrea sellaeformis XV 120
cubitus, Actinocyclus XX 40, XX 44
Cucullaea XVIII 70
culmula, Dichadogonyaulax XVIII 152
culmula cf., Dichadogonyaulax XVIII 148
cultrata limbata, Globorotalia (Globorotalia) XV 11, XV 20

cultrata limbata, Globorotalia (Menardiella) XVIII 26
cultrata menardii, Globorotalia (Globorotalia) XV 11, XV 20, XVI 145
cumingii, Cardium XVI 7
cumingii, Nemocardium (Lophocardium) XVI 30
cuneata, Rangia XII 247, XV 55, XVII 103, XVIII 108
cuneatus, Gnathodon XII 247
cuneiformis, Gastrochaena XII 161
cuneiformis, Hemidiscus XX 50, XX 56
Cuneolina XV 3
cunninghamae, Dermomurex (Trialatella) XI 130, XI146
cunninghamae, Trialatella XI 144
Cupanieidites orthoteichus XVII 29
Cupuliferoipollenites spp. XVII 29
curtulus, Brachidontes XIX 161, XIX 162
curtulus, Modiolus (Brachidontes) XIX 161
curvatulus, Actinocyclus XX 40, XX 44
CURVIDUCTUS, *Dermomurex (?Viator)* **XI 156,** *XI 158*
curvilineata, Aturia XII 14
Cushmanella sp. XVI 94
cushmani, Bairdoppilata (Bairdoppilata) XIV 137, XIV 146
cushmani, Nesidea XIV 137
cushmani, Rotalipora XI 306
Cushmanidea XII 62
ashermani XII 62
echolsae XII 62
sagena XIX 138
sp. XII 62, XII 74
tuberculata XII 62
cuspidatus, Basslerites XII 90
cuspidatus, Murex XIX 86
cuspidatus, Muricopsis XIX 86
Cussia praepaleacea XX 58
cuvieriana, Miliolina XI 274
CUVIERIDAE *XVII 102*
Cyathosphaera
crux XI 21, XI 193
diaphragma XI 195
CYCLAPOPHYSIS XII 182
MONMOUTHENSIS XII 183, *XII 198, XII 200*
Cyclinella tenuis XVII 104
Cyclococcolithina XI 24, XI 195, XIX 26
formosa XI 18, XI 24, XI 32, XI 195, XI 230
leptopora XI 24, XI 119, XV 14, XV 26, XIX 26
macintyrei XV 14, XV 26
reticulata XI 195, XI 230
robusta XIX 22, XIX 26
robusta cf. XIX 22, XIX 28
CYCLOCCOLITHOIDEAE *XIX 26*
Cyclococcolithus
annulatus XI 195
astroporus XI 196, XIX 28
formosus XI 24, XI 195
inversus XI 196
leptoporus XI 196, XV 14, XVI 87
luminus XI 236
lusitanicus XI 24, XI 195
macintyrei XV 14
mirabilis XV 14
neogammation XI 195
orbis XI 24, XI 195
reticulatus XI 195
CYCLOCLYPEINAE *XI 292*
CYCLOCYPRIDIDAE *XIV 155*
Cyclogyra XI 273
involvens XI 273, XI 280
planorbis XI 273, XI 280
CYCLOGYRINAE *XI 272*
Cyclolithella
annula XI 119
annulus XV 13
Cyclolithus robustus XIX 26
Cyclonephelium XII 206, XVII 30
distinctum XII 206, XII 220
Cyclopsiella veita XII 212, XII 220
Cyclorbulina XI 278
compressa XI 278
Cyclostremiscus
pentagonus XVII 100
suppressus XVII 100
Cyclostreon XV 50
Cylicargolithus
doronicoides XVIII 26
pelagicus XVIII 26
sp. XVIII 26
cylinderica, Oliva XVI 109
cylindrica, Argilloecia XII 60
cylindrica, Cytherideis XII 61
cylindrica cf., Neocytherideis XII 61, XII 74
cylindricus, Ophiraphidites XVI 129
cylindrus, Dendrogyra XIII 116
cylleniformis, Lyria (Enaeta) XIV 118
CYMATIIDAE *XVII 101*
Cymbaloporetta XI 294
squammosa XI 294
CYMBALOPORIDAE *XI 294*
cymbiformis, Arkhangelskiella XVII 32
Cyphoma XIII 113
Cypraea XI 96, XII 9, XV 48
Cypria XIX 147
aequalica XIX 148
aequalis XIX 147
pustulosa cf. XIV 155
sp. XIX 147
CYPRIDACEA *XII 59, XIV 139, XIX 147*
Cyprideis XIV 140
mexicana XIV 140, XIV 146
mexicana sp. cf. XIX 138
pascagoulaensis XIX 146
pascagoulaensis sp. aff. XIX 150
purperi purperi XIX 152
rohri XIX 150
salebrosa XIV 140, XIV 146, XIX 138, XIX 146
salebrosa cf. XII 70, XII 93
similis XIX 145
CYPRIDIDAE *XIX 147*
CYPRIDOPSIDAE *XIX 148*
CYPRINIDAE *XVI 41*
CYPRINOTINAE *XIX 147*
cyrano, Yochelcionella XVI 72

Cyrena elliptica XVI 8
Cyrillaceaepollenites
kedvesii XVII 29
megaexactus XVII 29
Cyrillona XVIII 161
dalli XVIII 161
Cyrtocapsa tetrapera XX 22
Cyrtocapsa (Cyrtocapsella) cornuta XX 22
Cyrtocapsella XX 22
cornuta XX 22
tetrapera XX 22, XX 24
Cyrtodaria XVIII 166
Cyrtopera laguncula XX 26
Cyrtopleura
costata XVII 104
sp. XVIII 107, XIX 113
CYRTOSOMA *XVI 61*
cyst forma *A XII 183, XII 200*
cyst forma *B XII 183, XII 200*
CYTHERACEA *XII 60, XIX 150*
Cythere
bahamensis XII 81
berchoni XII 89
bermudae XIV 145
danaiana XIV 154
fischeri XIV 148
margaritifera XII 84
pumicosa XII 88, XIV 154
rugipunctata XII 69, XIV 145
simplex XII 60
subrugosa XIX 155
Cythereis
cancellosa XVII 34
exanthemata gomillionensis XII 81
garretti XII 84
gomillionensis XII 81
rugipunctata XII 69, XIV 145
triplistriata XIV 154
Cytherella XII 92, XIV 156, XVI 86
fredricksburgensis XII 92
grossmani XII 93
guasarensis XII 93
hannai sp. cf. XIX 138
harpago XII 92
harpago cf. XII 92, XII 97
ovata XII 92
polita XII 93
pulchra sp. aff. XIX 139
sp. XIV 154, XIV 156, XIX 139
tuberculifera XII 92
tumidosa XII 92, XVII 34
turgidula XII 92
VERMILIONENSIS *XII 90,* **XII 92,** *XIX 138*
CYTHERELLIDAE *XII 92, XIV 156*
Cytherelloidea XII 93
castleberryensis XII 93
castleberryensis aff. XII 93, XII 97
leonensis XIV 156, XIX 139
leonensis sp. aff. XIV 154, XIV 156
sarsi XII 93
sullivani XVII 34
truncata XVII 34
umbonata XIX 139
umbonata sp. cf. XIX 139
Cytheretta
alexanderi XII 89
anderseni XIX 139
bassleri XIX 139
calhounensis XII 89
choctawhatcheensis XIX 139
daniana XII 86, XIV 154
howei XII 89
karlani XII 86
reticulata XII 86
sahnii XII 89
CYTHERETTINAE *XII 86, XIV 154*
CYTHERIDAE *XIX 155*
Cytheridea XIX 150
graciosa XIX 152
kollmanni XIX 146
longispina XIX 152
mediatena XIX 150
pebasae XIX 152
PURPERAE *XIX 148,* **XIX 150**
rohri XIX 150, XIX 152
setipunctata XIV 141
Cytheridea (Haplocytheridea)
bradyi XIV 140
proboscidiala XIV 140
wadei XIV 140
CYTHERIDEIDAE *XIV 140, XIX 150*
CYTHERIDEINAE *XIV 140*
Cytherideis
ashermani XII 62, XIV 141
cylindrica XII 61
Cytheridella XIX 154
boldi XIX 150, XIX 154
danielpopoli XIX 154
ilosvayi XIX 154
postornata XIX 154
cytheridellaformis, Perissocytheridea XIX 152, XIX 155
CYTHEROMATINAE *XII 78, XIV 152*
Cytheromorpha XIV 148
paracastanea XII 74, XIV 148, XIV 152
warneri XIX 139
Cytheropteron XII 64, XVI 86
alatum XII 64
barkeri XIX 139
hamatum XII 64, XII 74
hamatum sp. aff. XIX 139
latum XII 65
leonensis XII 68
MORGANI XII 65, *XII 74, XIX 139*
nodosum XIV 142
paralatissimum XII 65
subreticulatum XII 68
TUMULOSIMILIS XII 68, *XII 78*
yorktownensis XIX 139
Cytherura XII 63, XIV 141, XVI 86
elongata XII 64
forulata XII 64, XIV 142
johnsoni XII 63
johnsonoides XII 63
paradoxa XII 64
pseudostriata XIV 142

sandbergi XII 63, XII 74, XIX 139
sandbergi sp. cf. XIV 141, XIV 148
sp. A XII 63, XII 74, XIV 141, XIV 148, XIX 139
sp. B XII 64, XII 74, XIV 141, XIV 148
sp. C XIV 142, XIV 148
swaini XII 63, XII 74
wardensis XII 64, XIV 141, XIX 139
CYTHERURIDAE *XII 63,XIV 141*

D

dactylus, Lithophaga XIX 169
Daktylethra punctulata XI 10, XI 230, XI 238
daleki, Yochelcionella XVI 72
dalli, Acrosterigma (Acrosterigma) XIII 160, XIII 182, XVI 20, XVI 22
dalli, Cancellaria XII 42
dalli, Cardium XIII 160, XVI 5
dalli, Cyrillona XVIII 161
dalli, Lyria XIV 124
dalli, Modiolus XIX 168
dalli, Neolaganum XVIII 130
dalli, Turbinella XVIII 50
Dallimurex XII 102
Dallocardia XVI 6, XVII 55
danaiana, Cythere XIV 154
danaiana, Cytheretta XII 86, XIV 154
danaiana, Protocytheretta XIV 154
Danea californica XVII 37
daniana, Paracytheretta XIV 154
daniana, Protocytheretta XIV 154
danicus, Chiasmolithus XI 15, XIX 8
danielpopoli, Cytheridella XIX 154
danmoniensis, Crassina XVI 165
danmoniensis, Venus XVI 165
Daphnellopsis XI 97
lamellosa XI 97
murex XI 97
Darbyella XIV 88
Darbyellina XIV 88
darmooria cf., Deflandria XVII 37
dartmooria, Deflandrea XII 192, XII 212
darwinii, Asteromphalus XX 42, XX 46
Darwinula XIX 146
fragilis XIX 146
fragilis sp. aff. XIX 148
olivencae XIX 147
olivencae sp. aff. XIX 146
sp. XIX 146
DARWINULACEA *XIX 146*
DARWINULIDAE *XIX 146*
daubjergensis, Globigerina XII 176, XIX 13
daubjergensis, Globigerinoides XIX 13
daubjergensis, Globoconusa XIX 11
Daucina multicostata XIX 191
davanaensis cf., Nonionella XX 8
davidwhitei, Actinocythereis XII 82
deanei, Hystrichosphaeridium XII 187, XII 204, XII 206
decapetalus, Actiniscus XI 199
DECIDUA, *Trigoniocardia (Americardia) XIII 166, XIII 174,* **XIII 184**
decipiens, Cocconeis XX 43, XX 50
decipiens, Coscinodiscus XX 64
decipiens cf., Thalassiosira XX 62, XX 64
decora, Lyria XIV 109
decora, Macrocypris XII 59
decoraperta, Globigerina XV 11, XV 16, XVI 145, XVIII 24
decorata, Massilina XVIII 15
decorata, Prediscosphaera XIX 34
decorus, Arachnoidiscus XX 42, XX 46
decurrens, Aspella XI 125
decurrans, Fusus XI 125
decussata decussata, Micula XIX 32, XIX 44
decussata, Micula XIX 44
decussatus, Mytilus XIX 164
Decussicardium XVI 6
Deflandrea XII 191
acuminata XII 195
asymmetrica XII 191, XII 208
cooksonii XII 191, XII 210
darmooria cf. XVII 37
dartmooria XII 192, XII 212
diebelii XII 192, XII 212
diebelii cf. XII 192, XII 212, XVI 37
dilwynensis XII 193, XII 210
echinoidea XII 193, XII 210
granulifera XII 192, XII 200
limpida XII 193
magnifica XII 193, XII 210, XVII 37
microgranulata XII 195
minor XII 193, XII 210
obscura XVII 37
pannucea XII 194, XII 210, XVII 37
pentaradiata cf. XII 194, XII 214
phosphoritica XII 191
PULCHRA XII 194, *XII 214*
RHOMBOHEDRA XII 195, *XII 214*
SEVERNENSIS XII 195, *XII 216*
sp. A XII 196, XII 216
speciosa XII 196
speciosa cf. XII 196, XII 216
thomasii XII 200
tripartita XII 191
ventriosa XII 195
deflandrei, Circulodinium XII 208
deflandrei, Discoaster XI 56, XI 60
deflandrei, Palaeoperidinium XII 196
deflandrei cf., Palaeoperidinium XII 196, XII 216, XII 218
Deflandrius
cretaceus XIX 36
intercisus XIX 36
deformis, Engina XIX 66
deformis, Muricopsis (Risomurex) XIX 66, XIX 70
deformis, Ricinula XIX 66
deformis, Risomurex XIX 66
dehiscens, Sphaeroidinella XIV 25, XIV 52, XIV 60, XVI 94
dehiscens excavata, Sphaeroidinella XIV 52
dehiscens immatura, Sphaeroidinella XV 11, XV

22
dehiscens subdehiscens, Sphaeroidinella XV 12
dekayi, Eutrephoceras XII 237
dela, Campylosphaera XI 21, XI 192, XI 226
delessertii, Conus XIX 61
delicata, Dictyocha XX 86
delicatus, Amaurolithus XVIII 29, XVIII 35
delicatus, Discoaster XIX 9
delitiense, Peridinium XII 190
delitiense, Spongodinium XII 190, XII 208, XVII 30
delmontensis, Stichocorys XX 24
delphicum ballastrum, Cardium (Trachycardium) XIII 158
Delphinula trigonostroma XII 42, XII 44
delus, Chiasmolithus XI 193
delus, Coccolithites XI 21, XI 193
delus, Coccolithus XI 21, XI 193
delus, Cruciplacolithus XI 21, XI 22, XI 26, XI 193
demarcoi, Voluta XIV 127
demens, Nonion XVIII 160
demens, Nonionoides XVIII 160
demissa granosissima, Geukensia XVII 102
demiurgus, Conus XII 7, XII 10
DEMOSPONGEA *XVI 125*
Dendrogyra cylindrus XIII 116
DENDROPHYLLIIDAE *XI 173*
DENDROPHYLLIINA *XI 173*
densa, Acaranina XI 11
densata, Mulinia XVI 43
densata, Venericardia XV 71
densispinatum, Spinidinium XVII 30
DENTALIIDAE *XVII 104*
Dentalina
colei XVII 35
communis XVI 92
filiformis XVI 92
legumen XIV 83
subarcuata XIV 83
Dentalium
sp. XVII 104
texasianum XVII 104
dentata, Spiroloculina XVI 92
dentatum, Microdinium XII 220
dentatus, Ceratolithus XI 116
Denticella tridens XX 43
Denticula
dimorpha XX 48
fossilis XX 48
hustedtii XX 48
hyalina XX 48
kamtschatica XX 48
lauta XX 46
seminae XX 48
denticulata, Antarctissa XX 18, XX 20
denticulata, Lithobotrys XX 18
denticulata, Lithopera XX 18
denticulata, Spirillina XI 288
denticulatus, Heliorthus XIX 30, XIX 42
Denticulopsis XX 46
dimorpha XX 46, XX 54
fossilis XX 8, XX 48, XX 54
hustedtii XX 48, XX 54
hyalina XX 48, XX 54
kamtschatica XX 8, XX 48, XX 54
seminae XX 48
dentilabris, Terebralia XVI 159
depressa, Heterostegina XI 294
depressula matagordanum, Nonion XI 298
depressulum matagordanum, Nonion XI 298
deprimus, Cibicides XI 294
Dermomurex XI 127, XI 133, XII 45, XII 102, XVI 45
acuticostatus XI 127
alabastrum XII 46
cotteauvi XI 127
engonatus XII 46
indentatus XI 129, XII 45
obeliscus XI 129
pachystirus XI 127
pauperculus XII 45
quilonicus XI 127
transsylvanicus XI 127
Dermomurex (Dermomurex)
alabastrum XII 45
engonatus XI 136, XI 142
MATERCULA XI 133, *XI 138*
pauperculus XI 138
scalaroides XI 127, XI 150
tenellus XI 128, XI 138
Dermomurex (Gracilimurex)
elizabethae XI 141, XI 142
elizabethae cf. XI 141, XI 142
Dermomurex (Takia)
COOKEI XI 149, *XI 150*
distinctus XI 150
infrons XI 149, XI 150
myrakeenae XI 150
Dermomurex (Trialatella)
abyssicola XI 146, XI 148
ANTECESSOR XI 145, *XI 146*
arlus XI 128, XI 146
cunninghamae XI 130, XI 146
FARLEYENSIS XI 144, *XI 146*
jani XI 144, XI 146
Dermomurex (Viator)
antonius XI 150, XI 154
asteriscus XI 153, XI 154
CURVIDUCTUS XI 156, *XI 158*
sexangulus XI 152, XI 154
taurinensis XI 158
vaughani XI 153, XI 158
deroyae, Admetula XII 39
deroyae, Agatrix XII 39
deshayesiana, Dimya XV 38
DESMIDIDAE *XIII 61*
Deuteromya XV 38
intusstriata XV 50
Diadema antillarum XIII 114, XIII 126
diadema, Chaetoceros XX 43, XX 48
diadema, Syndendrium XX 43
diaphragma, Coccolithus XI 195
diaphragma, Cyathosphaera XI 195
Diartis petterssoni XX 6
DIASOMA *XVI 61*

Diastoma varium XVII 100
diastypus, Discóaster XI 56, XI 60, XIX 9
Diatoma auritum XX 42
DIATOMACEAE *XIII 61, XV 59, XX 39*
Diberus XIX 170
Dicasignetella XVI 82
Dichadogonyaulax XVIII 152
culmula XVIII 152
culmula cf. XVIII 148
IRREGULARE *XVIII 150,* **XVIII 154**
pannea XVIII 148
rotunda XVIII 152
schizoblata XVIII 152
sellwoodii XVIII 152
sp. B XVIII 148
stauromatos XVIII 152
dicladia, Chaetoceros XX 43, XX 48
Diconodinium XII 212
rhombiformis XII 212, XII 220
Dicranodonta XVIII 71
Dictyocha XX 85
aspera XX 85
ausonia XX 86
bisecta XX 86
boliviensis XX 88
brevispina XX 86, XX 90
clinata XX 85, XX 88
complexa XX 86, XX 88
crux XX 90
delicata XX 86
fibula XX 86, XX 88, XX 90
lingi XX 88
longispina XX 86
medusa XX 88, XX 90
mesophthalma XX 90
minuta XX 92
mutabilis XX 86
parva XX 90
pentagona XX 86, XX 88
pseudofibula XX 86
polyactis XX 90
pulchella XX 86, XX 88
rhombica XX 86
schauinslandii XX 92
sp. XX 88
speculum XX 92
stradneri XX 92
Dictyocha (Mesocena)
circulus XX 94
elliptica XX 94
triagula XX 94
DICTYOCHACEAE *XX 85*
Dictyococcites XI 28
bisectus XI 197
callidus XI 197
dictyodus XI 197
dictyoda, Reticulofenestra XI 196, XI 197
dictyodus, Dictyococcites XI 197
dictyodus, Stradnerius XI 197
Dictyophimus XX 22
crisiae XX 22
sp. XX 22, XX 24
Didymocyrtis antepenultima XX 6
diebelii, Ceratiopsis XII 192
diebelii, Deflandrea XII 192, XII 212
diebelii cf., Deflandrea XII 192, XII 212, XVII 37
difformis, Clavulina XI 272
digitata, Globigerina XIV 17, XIV 34
dilatata, Crepipatella XI 170
dilatata, Crepidula XI 166
dilatus, Momipites XVII 38
dilectus, Chicoreus (Chicoreus) XI 87
dilectus var., Chicoreus (Chicoreus) XI 87, XI 88
dilwynensis, Deflandrea XII 193, XII 210
Dimerogramma XX 48
sp. XX 48, XX 54
dimorpha, Denticula XX 48
dimorpha, Denticulopsis XX 46, XX 54
dimorphosum, Biscutum XIX 36
dimorphosus, Prinsius XIX 26, XIX 36
Dimya XV 38
ALLENI XV 38, *XV 40*
argentea XV 49
bonneti XV 49
california XV 49
checchiai XV 50
coralliotis XV 50
corrugata XV 38
crearoi XV 50
deshayesiana XV 38
dissimilis XV 50
extenuiplicata XV 50
filipina XV 50
FIMBRICOSTATA XV 44, *XV 46*
fragilis XV 50
fragilis crassiplicata XV 50
fragilis miopliocenica XV 50
fragilis punctata XV 50
grandis XV 40, XV 42
grandis divaricata XV 42
internostriatum XV 50
intusstriata XV 50
intustriata XV 50
japonica XV 50
kaiparaensis XV 50
libyca XV 50
lima XV 50
maoria XV 50
mimula XV 50
molokaia XV 50
obliqua XV 50
pamplomensis XV 50
radiata XV 50
radiata takii XV 50
raulini XV 50
richei XV 50
RUFARIPA XV 39, *XV 40*
sigillata XV 50
sp. XV 40, XV 49
spondyliformis XV 50
subrotunda XV 51
tigrina XV 46, XV 48
westonensis XV 51
DIMYACEA *XV 38*
Dimyarina XV 38
Dimyella XV 34

starki XV 34
DIMYIDAE *XV 38*
Dimyodon XV 40
boehmi XV 51
böhmi XV 51
costatus XV 51
dissimilis XV 50
intusradiatum XV 51
nilssoni XV 51
plicatuloides XV 51
richthofeni XV 51
schlumbergi XV 51
sigillina XV 51
similis XV 51
similis interstricta XV 51
storrsi XV 51
woehrmanni XV 51
wöhrmanni XV 51
Dimyopsis XV 50
dinesenii, Helicopontosphaera XI 214
dingdenensis, Voorthuyseniella XII 158
Dinocardium XIII 185, XVI 6
alumen XIII 186
chipolanum XIII 174, XIII 178, XIII 185
robustum XVII 103, XVIII 120, XIX 61
Dinocardium (Exocardium) chipolanum XIII 185
DINOFLAGELLATE *XII 169*
Dinogymnium XII 180
sp. XII 180, XII 226, XVII 37
westralium XII 181, XII 198
DINOPHYCEAE *XII 180, XVIII 148*
diodon, Challengeron XX 32, XX 34
diodon, Mesocena XX 94, XX 100
Diodora XIX 78
cayenensis XVII 100, XIX 61
Diphyes XII 184
colligerium XII 184, XII 200
Diploctenium XI 173
Diplodonta
notata XIX 108
semiaspera XVII 103
soror XVII 103
Diploneis XX 48
crabro XX 48, XX 54
Diploria
clivosa XIII 118
strigosa XIII 118, XIII 128
Diplothyra smithii XVII 104
directus, Ensis XVIII 117, XIX 108
discipulus, Choanopollenites XVII 39
Discoaster
aster XI 56, XI 58
asymmetricus XI 120, XV 13, XV 26
barbadiensis XI 56, XI 59, XI 61, XI 62, XI 198, XI 232
binodosus XI 56, XI 59, XI 60, XI 61, XI 199, XIX 9
binodosus hirundinus XI 56, XI 60, XI 62, XI 199
boulangeri XI 61
bramlettei XI 204
broweri XI 80, XI 120, XV 13, XV 26, XVI 146, XVIII 26
deflandrei XI 56, XI 60
delicatus XIX 9
diastypus XI 56, XI 60, XIX 9
distinctus XI 61, XI 66, XI 72
elegans XI 61, XI 62, XI 66, XI 199, XI 232
exilis XV 13, XV 26
furcatus XI 69
gemmeus XIX 9
hayi XII 166
helianthus XIX 9
hirundinus XI 60, XI 199
kuepperi XI 69
lenticularis XI 58, XI 64, XIX 9
limbatus XIX 9
lodoensis XI 56, XI 64, XI 72
mediosus XIX 9
mirus XI 58, XI 62, XI 64
multiradiatus XIX 9
nobilis XIX 9
nodifer XI 60, XI 66, XI 199, XI 232
pentaradiatus XI 58, XI 120, XI 198, XV 14, XV 26, XVI 146, XVIII 26
perplexus XV 14, XV 26
perpolitus XIX 9
quinqueramus XI 115, XI 120
saipanensis XI 58, XI 61, XI 72, XI 200, XI 232
sp. A XI 200, XI 232
staurophorus XIX 44
stella XI 65, XI 66
stradneri XI 61
sublodoensis XI 56, XI 65
surculus XI 120, XV 16, XV 28, XVI 146, XVIII 26
tani XI 68, XI 199
tani nodifer XI 60, XI 65, XI 66, XI 199
triangularis XI 66, XI 68, XI 72
tumescens XI 58, XI 62, XI 68
variabilis XI 120, XV 16, XV 28, XVIII 32
woodringi XI 66, XI 68
DISCOASTERACEAE *XI 58*
Discoasteroides XI 69
kuepperi XI 66, XI 69, XI 72
Discocyclina XVII 135
advena XI 181
discoidale, Elphidium XVI 92
Discolithina XI 206, XIX 40
amphitheatralis XI 34, XI 210
aperta XI 210
bicaveata XI 206, XI 240
confussa XI 30, XI 208
cribraria XI 206, XI 238
distincta XI 30, XI 208
enormis XI 208
macroporus XV 14
multipora XI 30, XI 206, XI 208, XI 238, XV 14
obliquipons XI 222
ocellata XI 34, XI 206
panarium XI 31
pectinata XI 31
plana XI 31
pulcheroides XI 35, XI 222
pulchra XI 35, XI 220
solida XI 240

sp. A XI 210, XI 238
sp. B XI 210, XI 242
versa XI 32, XIX 20, XIX 40
vesca XI 208, XI 238
viginitiforata XI 208
wechesensis XI 210, XI 242
Discolithus
confussus XI 30, XI 208
crassus XI 30
cretaceus XIX 36
distinctoides XI 30, XI 208
distinctus XI 30, XI 208
exilis XI 218
fenestratus XI 196
fimbriatus XI 210, XI 220
lineatus XI 206
macroporus XI 240, XV 14
multiporus XI 30, XI 206, XV 14
obliquipons XI 218, XI 220, XI 222
ocellatus XI 34
pectinatus XI 31
planus XI 31
pulcher XI 35, XI 220
pulcheroides XI 35, XI 220
pulchriporus XI 39, XI 220
solidus XI 240
spinosus XI 226
versa XIX 40
versus XI 31
viginitiforatus XI 206, XIX 40
Discopulvinulinella bertheloti XVI 92
DISCORBACEA *XI 284*
DISCORBIDAE *XI 284*
DISCORBINAE *XI 284*
Discorbis XI 284, XIX 182
floridanus XI 286
mira XI 286, XI 292
rosea XI 286
sp. XVII 35
Discors XVI 6
discors, Cardium XVI 6
discors, Mytilus XIX 165
DISCORS, *Volvarina* **XI 308**
Discosphaera tubifera XI 182
discrepans, Cardium XVI 6
discrepans, Nemocardium (Divaricardium) XVI 34
discula, Braarudosphaera XI 42, XI 48, XI 188, XVII 31, XIX 8
discus, Dosinia XVII 104
DISINFLATUS, *Musculus (Planimodiola) XIX 162,* **XIX 168**
disjuncta, Heterocibicides XIV 103
disjuncta, Sphaeroidinella XV12
dislocata, Terebra XVII 102, XIX 61, XIX 109
dislocatum, Strioterebrum XVIII 61
dispar, Lucianorhabdus XI 244
disrupta, Cocconeis XX 43
dissidepictum, Agnocardia XVIII 42
dissidepictum, Cardium (Acanthocardia) XIII 153, XVIII 42
dissimilis, Conger XV 100, XV 102
dissimilis, Dimya XV 50
dissimilis, Dimyodon XV 50
distans floridana, Astarte XVI 167
Distephanus XX 88
bispicatus XX 92, XX 94
boliviensis XX 88, XX 92
corontata XX 92, XX 94
crux XX 90
frugalis XX 90, XX 94
jimlingii XX 90, XX 96
longispina XX 90
longispinus XX 90, XX 92
mesophthalmus XX 90, XX 94
minutus XX 92, XX 94
parvus XX 90, XX 92
pentagonus XX 90
polyactis XX 90, XX 92
pseudofibula XX 88, XX 92
quinquangellus XX 90
sp. XX 90, XX 92, XX 94, XX 98
speculum XX 92, XX 94
stradneri XX 92, XX 98
disticha, Miliola XVIII 6
Distichotyphis XI 97
distichus, Ellipsolithus XIX 9
distincta, Discolithina XI 30, XI 208
distinctoides, Discolithus XI 30, XI 208
distinctum, Cyclonephelium XII 206, XII 220
distinctus, Dermomurex (Takia) XI 150
distinctus, Discoaster XI 61, XI 66, XI 72
distinctus, Discolithus XI 30, XI 208
distinctus, Murex XI 127
Distorsio clathrata XVII 101
Divaricardium XVI 6
divaricata, Crenella XIX 164
DIVERSISPINA XII 184
TRUNCATA XII 184, *XII 200*
divisus, Actinocyclus XX 40
divisus, Tagelus XVII 104
dixie, Plagiobrissus XVIII 131
Dochmocardia XVI 6, XVI 40
doderleini, Paraster XVIII 135
dodona, Conus XII 22, XII 24
dolichodeira, Krithe XII 61
Dolicholathyrus XIII 196
Dolicholatirus XIII 196
exilis XIII 196, XIII 197
torquatus XIII 195
DOLIIDAE *XIX 178*
doliolus, Pseudoeunotia XX 56, XX 58
doliolus, Synedra XX 56
Doliopsis XIX 178
Dolium XIX 178
crosseanum XIX 178
Dolium (Eudolium) subfasciatum XIX 179
domingensis, Dreissena XVIII 165
domingensis, Mytilopsis XVIII 165
DOMINICANA, *Vitularia XIII 193,* **XIII 194**
dominicense, Trachycardium (Dallocardia) XVII 56
dominicense, Vasum XV 110, XV 113
Donacicardium XVI 6
DONACIDAE *XVII 103*
donaciforme, Cardium XVI 7

donaciformis, Hemidonax XVI 22
Donaciocardium XVI 6
Donax XVI 159
pictus XVI 7
texasianus XVII 103
variabilis roemeri XVII 103
Dorcadospyris alata XX 6
doris, Harpa XVIII 54
doris, Paracardium XVII 48
doronocoides, Coccolithus XI 119, XV 13, XV 24
doronicoides, Cylicargolithus XVIII 26
dorsata, Crepidula XI 166
dorsata, Crepipatella XI 170
Dosinia XVIII 166
discus XVII 104
Dossetia XX 48
lacera XX 48, XX 54
drakeana, Asclepias XIII 29
draperi, Conus XII 21
Dreissena XVIII 164
domingensis XVIII 165
DREISSENIDAE *XVIII 163*
DRESSENIDAE *XVII 104*
drezi, Concholepas XVI 159
DREZI, *Conus* **XII 24,** *XII 26*
DREZI, *Pygmaepterys* **XVI 48,** *XVI 50*
druidi, Trigonostoma XII 44
Drupa XIX 64
morum XIX 64
uva XIX 64
Drupa (Morula) gilbertharrisi XIX 78
druryi decoraperta, Globigerina XV 11
dryas, Cheilea XI 170
dubia, Pseudopyxilla XX 56, XX 58
dubia, Pyxilla XX 56
dubia, Rotalia XI 288
dubia, Rotalina XI 288
dubia, Venericardia XVI 41
dubitalis, Poirieria (Panamurex) XII 103
dubium, Cladogramma XX 43, XX 50
dubius, Chiphragmalithus XI 70, XI 238
dubius, Neococcolithes XI 52, XI 66, XI 70, XI 238
dubius, Zygolithus XI 70, XI 234, XI 236
ducatellii, Modiola XIX 171
ducatelii, Modiolus XIX 66, XIX 171
ducatelli, Venus XIX 171
DUGONGIDAE *XIV 162*
dujardinoides, Chicoreus XI 83, XV 108, XV 112
dumosum, Cardium XVI 6
dumosum, Granocardium (Criocardium) XVI 14, XVI 16
dumosus, Spondylus XII 141
duocavus sp. cf., Lanternithus XVII 31
dupiniana, Cardita XVI 42
dupiniana, Venericardia XVI 41
dupinianum, Cardium XVI 7
dupinianum, Integricardium (Integricardium) XVI 30, XVI 32
duplex, Trochoaster XI 55, XI 204
duplicatus, Neverita XVII 101
duplicatus, Polinices XVIII 117, XIX 61
Durhamella XVIII 137
floridanum XVIII 130
ocalanum XVIII 130
dutertrei, Globigerina XIV 58
dutertrei, Globoquadrina XIV 28, XIV 58, XIV 64
dutertrei, Neogloboquadrina XVI 94
Dyopteris
aureliana XIII 61
normalis XIII 61
rafinesquiana XIII 61
versicolor XIII 61

E

eboreus darlingtonensis, Pecten XVI 97
eburneus, Balanus XVI 99
echinata, Henryhowella XII 85
echinata, Ricinula XIX 86
echinatum, Microdinium XII 220
Echinocardium cordatum XVIII 134
ECHINOCYTHEREIDINAE *XII 84*
Echinocythereis XII 84, XVI 86
garretti XII 84
margaritifera XII 84, XII 90, XIX 139
sp. XIX 139
echinoidea, Deflandrea XII 193, XII 210
Echinolampas
aldrichi XVIII 130
tanypetalis XVIII 130
Echinometra lucunter XIII 114
Echinoneus XVIII 137
echinus, Boreotrophon XII 120
echolsae, Cushmanidea XII 62
economia, Enaeta XIV 115
economia, Lyria (Enaeta) XIV 115
Ecphora XV 6, XVI 98
ecuadoriale, Cardium XVI 6
ecuadorialis, Cardium XVI 6
ecuadorialis, Cardium (Dinocardium) XIII 185
ecuadoriana, Trigonostoma XII 43, XII 44
Edentostomina XI 273
sp. XI 273, XI 283
edule, Cardium XV 16
edule, Cerastoderma XVI 36, XVI 38
Edulicardium XVI 6
EDWARDSI, *Megacythere* **XIV 150,** *XIV 152*
EGGERELLIDAE *XIX 185*
EGGERELLINAE *XIX 185*
eggeri, Neogloboquadrina XVI 94
egregius, Coscinodiscus XX 46, XX 54
ehrenbergi, Anthocyrtidium XX 28
ehrenbergi, Cribrosphaera XIX 42
ehrenbergii, Actinocyclus XX 40, XX 44
ehrenbergii, Arachnoidiscus XX 42, XX 46
ehrenbergii, Cribrosphaerella XIX 34, XIX 42
ehrenbergii, Navicula XX 52, XX 56
Eisenackia XII 183
Eiffellithus XIX 34
turriseiffeli XIX 34
Ekokenia sp. XV 100, XV 103
elattocostatum, Cardium (Fragum) XIII 181
eldridgei, Wythella XII 141, XVIII 132

Electra XVII 111
spp. XVII 111, XIX 108
elegans, Amphitetras XX 66
elegans, Discoaster XI 61, XI 62, XI 66, XI 199, XI 232
elegans, Epistomina XV 6
elegans, Hoeglundina XVI 92
elegans, Triceratium XX 64, XX 66
elegantissima, Bulimina XI 280
elegantissima, Buliminella XI 280, XI 290
elegantulum, Ctenidodinium XVIII 150
Energlynia XVIII 152
elizabethae, Aspella XI 141
elizabethae, Aspella (Dermomurex) XI 141
elizabethae, Dermomurex (Gracilimurex) XI 141, XI 142
elizabethae cf., Dermomurex (Gracilimurex) XI 141, XI 142
Ellipsoglandulina multicostata XIX 191
Ellipsolithus
distichus XIX 9
macellus XIX 8
Ellipsonodosaria
plummerae XVII 35
sp. XVII 35
Ellipsoplacolithus
exsectus XV 13
galenis XV 13
lacunosus XV 13
elliptica, Basterotia (Basterotella) XVI 162
elliptica, Cyrena XVI 8
elliptica, Dictyocha (Mesocena) XX 94
elliptica, Mesocena XX 94, XX 100
elliptica, Rhabdosphaera XIX 34
ellipticus, Actinocyclus XX 41, XX 44
ellipticus, Clathrolithus XIX 9
ELLOBIIDAE *XVII 102*
elongata, Brissopsis XVIII 135
elongata, Cepekiella XI 236
elongata, Cytherura XII 64
elongata, Globigerina XIV 40
elongata, Rhaphoneis XX 56, XX 58
elongatum, Acrosterigma (Vasticardium) XIII 161, XIII 182
elongatum, Cardium XIII 160, XVI 8, XVI 36
elongatum peregrinum, Eucyrtidium XX 26
elongatum, Trachycardium XIII 161
elongatum, Vasticardium XIII 162, XVI 20, XVI 36
elongatus, Globigerinoides XIV 21, XIV 40, XIV 48
ELOPIFORMES *XV 102*
ELPHIDIIDAE *XI 290*
ELPHIDIINAE *XI 290*
Elphidium XI 290, XIX 182
advenum XI 290, XI 296
discdoidale XVI 92
fimbriatulum XVI 92
galvestonense XI 290
galvestonensis XI 290
gunteri XVI 94
gunteri galvestonense XI 290, XI 296
gunteri galvestonensis XI 290
incertum XVI 94
incertum mexicanum XI 292
mexicanum XI 292
poeyanum XI 292
sagrum XI 292, XI 296
spp. XVI 94, XIX 131
ELUSIVUS, *Chicoreus (Chicoreus)* **XI 82**, *XI 84*
Emiliania
annula XV 13, XV 26, XVIII 26
huxleyi XI 120, XVI 85
EMILYANA, *Gastochaena (Spengleria) XII 161,* **XII 162**
eminens, Coccolithus XI 21
eminens, Cruciplacolithus XI 21, XI 22
Enaeta XII 114
americana XIV 115
barnesii XIV 115
economia XIV 115
isabellae XIV 115
perturbatrix XIV 118
Enantiocristellaria XIV 88
Encope XVIII 137
michelini XVIII 141
Endictya XX 48
oceanica XX 48, XX 54
robusta XX 50
robustus XX 50, XX 54
Endopachys XI 173
alatum XI 173
grayi XI 173
japonicum XI 173
lonsdalei XI 173
maclurii XI 174
minuta XI 173
oahense XI 173
shaleri XI 173
TAMPAE XI 173, *XI 174*
Engina XIX 63
deformis XIX 66
rosea XIX 68
rutila XIX 80
schrammi XIX 76
zonata XIX 64
engonata, Aspella XI 136
engonata, Aspella (Aspella) XI 136
engonatus, Aspella XI 136
engonatus, Aspella (Dermomurex) XI 136
engonatus, Dermomurex XII 46
engonatus, Dermomurex (Dermomurex) XI 136, XI 142
engonatus, Trophon (Aspella) XI 136
enigmatica, Sujkowskiella XI 244
enode, Laevicardium (Trachycardium, Acrosterigma) XVI 38
enormis, Discolithina XI 208
ensiforme, Paracytherois XII 76
ensiforme, Paradoxostoma XII 76, XII 78, XII 82
ensiformis, Paracytherois XII 76
Ensis
directus XVIII 117, XIX 108
minor XVII 103
Enterosolenia
lucida XI 279

marginata lucida XI 279
Entobia XIX 55
Entopyla XX 50
australis XX 50
gigantea XX 50, XX 54
eocenia, Falsilyria XIV 120
Eocithara XVIII 53
eodela, Campylosphaera XI 193
Eoflabellina XIV 88
Eomiltha XVII 135
eopelagicus, Coccolithus XI 13, XI 16, XI 24, XI 25
eopelagicus, Tremalithus XI 13
eos, Cardium XVI 6
eos, Nemocardium (Frigidocardium) XVI 34
Eosolea XV 99
texana XV 100, XV 103
Eouvigerina parvula XVI 94
Ephedra
claricristata XVII 29
hungarica XVII 28
voluta XVII 39
Epistomina elegans XV 6
EPITONIIDAE *XVII 100*
Epitonium
angulatum XVII 100
multistriatum XVII 100
rupicola XVII 100
togatum XVI 155
tollini XVII 100
Epitonium (Cirsotrema) togatum XVI 155
epomis, Agatrix XII 36, XII 38
epomis, Tribia XII 38
Eponides
antillarum XIX 131
sp. XVII 35
equadorana, Vitularia XIII 193
equestris, Cheilea XI 168, XI 171
equestris, Patella XI 170, XI 171
EQUIDAE *XI 110*
Equus XV 60
major XV 59
erbessina, Nodosaria XIX 191
Ergalatax XIV 131
bicatenatus XIX 70
infans XIX 86
nitens XIX 87
Ericipites ericus aff. XVII 29
ericius aff., Ericipites XVII 29
Ericsonia XI 25, XI 196
alternans XI 195
cava XIX 18
fenestrata XI 196, XI 240
formosa XI 195
martinii XIX 38
muiri XI 25, XI 28, XI 32, XI 194
occidentalis XI 25, XI 196
ovalis XI 25
quadriperforata XI 196
samodurovi XI 198
singularis XI 196
subdisticha XI 196
subpertusa XVII 31
ericsoni, Cassidulus XVIII 138
Erigidocardium XVI 6
ERIMIOCENICUS, *Mytilopsis* **XVIII 164**
erinaceum, Cardium XVI 38
erosus, Murex XI 122
ERUGATUS, *Conus* **XII 17,** *XII 18*
Ervilia concentrica XVII 103
Erycina floridana XIX 108
Esolea texana XV 103
esterae, Cromydruppocarpus XX 13, XX 14
Esthonyx XV 82
Ethmocardium XVI 6
Eucardium XVI 6
Eucharis XVI 160
Eucidaris tribuloides XIII 114
Eucommia XVII 29
Eucrassatella speciosa XIX 61
eucteanus, Typhis (Talityphis) XVII 125, XVII 126
Eucythere
midwayensis XVII 34
sp. XII 93, XII 97
triangulata sp. aff. XIX 139
Eucytherura spp. XIX 139
Eucyrtidium XX 24
acuminatum XX 30
calvertense XX 24
calvertense sp. cf. XX 22, XX 24
elongatum peregrinum XX 26
matuyami XX 28
Eudolium XIX 178
antiquum XIX 177
aoteanum XIX 179
biornatum XIX 177
crosseanum XIX 178
inflatum XIX 178
muticum XIX 179
pyriforme XIX 178
subfasciatum XIX 177
thompsoni XIX 177
Eudolium (Galeodolium) XIX 178
muticum XIX 177
subfasciatum XIX 178
s. conica XIX 178
s. crassilabiata XIX 178
s. inflata XIX 178
s. magnovoidea XIX 178
s. oblongata XIX 178
s. pantanensis XIX 178
s. percostata XIX 178
s. subtuberculata XIX 178
s. supratuberculata XIX 178
s. trilatetuberculata XIX 178
s. tuberculifera XIX 178
s. unituberculifera XIX 178
eugubina, Globigerina XIX 11
Euleraphe XVI 129
Eulima bilineatus XVII 101
Eulimastoma
teres XVII 102
weberi XVII 102
EULIMIDAE *XVII 101*
Eumodiolus XIX 171

Eupatagus
antillarum XVIII 131
ingens XVIII 130
ocalanus XVIII 130
Euphorbia herronnii XIII 18
EUPLECTELLIDAE *XVI 136*
EUPLECTELLOIDEA *XVI 136*
Eupleura XI 96, XI 122
sexangula XI 152
stimpsonii XII 110, XVI 46
subanceps XI 126
Eupodiscus tenellus XX 41
Eurete XVI 138
formosum XVI 138
mantelli XVI 138
Eurhodia XII 143, XVIII 73
Europicardium XVI 6
Eusmilia fastigiata XIII 118
Eusthenopteron XVI 58
Eutrephoceras XII 237
berryi XII 238, XII 240
bryani XII 238, XII 240
carolinensis XII 238, XII 240
cookanum XII 238, XII 240
dekayi XII 237
sloani XII 237, XII 238, XII 240
Eutritonium XI 97
evax, Henryhowella XII 84
evittii, Trithynodinium XII 197
evulsa, Admetula XII 38
evulsa, Buccinum XII 38
evulsa, Cancellaria XII 38
exanthemata cf., Actinocythereis XIV 152
exanthemata gomillionensis, Actinocythereis XII81
exanthemata gomillionensis, Cythereis XII 81
exanthemata gomillionensis, Trachyleberis XII 81
excavata, Perissocytheridea XII 70, XII 93
excelsa, Koczyia XI 34, XI 210
excentrica, Thalassiosira XX 62, XX 64
excentricus, Coscinodiscus XX 43
exigua cf., Pseudoparella XVII 35
exiguum commutata, Cardium XVI 8
exile, Punicum XIII 61
exilimurum, Inversidinium XII 218
exilis, Discoaster XV 13, XV 26
exilis, Discolithus XI 218
exilis, Dolicholatirus XIII 196, XIII 197
exilis, Latirofusus XIII 197
exilis, Transversopontis XI 218, XI 240
Exocardium XIII 185, XVI 6
exocha, Ctenocardia (Afrocardium) XVI 24
Exochosphaeridium XII 185
bifidum XII 185, XII 202
phragmites XII 185
sp. XII 185, XII 202
Exogyra
cancellata XII 176
costata XII 178
expansus, Chiasmolithus XI 16, XI 18, XI 193
expansus, Coccolithus XI 18
expansus, Typhis XVII 124
Exputens ocalensis XII 143
exsectus, Ellipsoplacolithus XV 13
extenuiplicata, Dimya XV 50
Extremipollis vivus XVII 36
exustus, Brachidontes XVII 102
exuvia, Nerita XVII 131
exuvia, Nerita (Theliostyla) XVII 132
exuvioides, Nerita (Nerita) XVII 132
exuvioides, Nerita (Theliostyla) XVII 132

F

FABULARIDAE *XVIII 4*
fadeewi, Physocypria XIV 156
Faguspollenites sp. XVII 30
falcifer, Lenticulina XVI 92
falconensis, Globigerina XIV 17, XIV 34, XVI 94
falconensis, Turbinella XVIII 47
falconensis, Xancus XVIII 52
fallax, Heliorthus XIX 30
falsificum, Alvellodinium XVIII 152
Falsilyria XIV 120
ANOPTOS *XIV 124,* **XIV 127**
citrusensis XIV 122
eocenia XIV 120
mansfieldi XIV 122, XIV 124
musicina XIV 122, XIV 124
pycnopleura XIV 124, XIV 126
vaughani XIV 124, XIV 128
Fargoa XVII 105
FARLEYENSIS, *Dermomurex (Trialatella)* **XI 144,** *XI 146*
farox, Trionyx XVII 71
fasciata, Melongena XVI 149
fasciata, Pugilina XVI 149
fasciata, Tegula XI 168
Fasciculithus
involutus XIX 9
tympaniformis XIX 8
Fasciolaria XIII 195, XV 113
gigantea XIII 195 XV 113
gorgasiana XV 114
intermedia XV 113
kempi XV 108, XV 113
lilium hunteria XVII 101
semistriata XV 113
textilis XVIII 52
tulipa XV 113
FASCIOLARIIDAE *XV 105, XVII 101*
FASCIOLARIINAE *XII 134, XIII 196*
Fasciolites XVIII 20
fastigiata, Eusmilia XIII 118
fatula, Rhaphoneis XX 56, XX 58
Favartia XI 122, XIII 193, XVI 46, XIX 63
cellulosa XVI 47
kurodai XVI 47
Favella rugipunctata XII 69, XIV 145
faveolata, Planulina XVI 92
Favitricolporites baculoferus XVII 39
fenestrata, Ericsonia XI 196, XI 240

fenestratus, Discolithus XI 196
FERAYI, TEXINA *XVIII 12,* **XVIII 17**
fergusoni, Conus XII 9
ferox, Baltisphaeridium XII 186
ferox, Claenodon XV 78
ferox, Hystrichokolpoma XII 186, XII 204
ferox, Hystrichosphaeridium XII 186
ferruginea, Sistrum XIX 67
ferrugineum rubidum, Sistrum XIX 66
ferruginosa, Ricinula XIX 67
festiva, Ctenocardia (Microfragum) XVI 22
festivum, Cardium XVI 7
Fibradinium XII 214
annetorpense XII 214
annetorpense cf. XII 214, XII 222
Fibrocysta
bipolare XVII 28
sp. XVII 37
fibrospinosum, Cordosphaeridium XII 182, XII 198
fibula, Dictyocha XX 86, XX 88, XX 90
Fibularia XVIII 137
vaughani XVIII 130
fichteliana, Miliolinella XI 276, XI 286
fichteliana, Triloculina XI 276
FICIDAE *XVII 101*
Ficus communis XVII 101
filicata, Peristernia XII 110
filiforme, Syringodium XI 259
filiformis, Dentalina XVI 92
filiformis, Gaudryina XIX 185
filipina, Dimya XV 50
filisolaensis, Cibicides XV 6
fimbriata, Globorotalia XVI 94
fistulosa, Globigerina XIV 42
fistulosus, Globigerinoides XIV 42, XIV 46
filum, Gymnodinium XII 181
fimbriata, Hystrichokolpoma XII 187, XII 204
fimbriata, Koczyia XI 220
fimbriatulum, Elphidium XVI 92
fimbriatum, Cardium XVI 38
fimbriatus, Discolithus XI 210, XI 220
fimbriatus, Transversopontis XI 220, XI 242
FIMBRICOSTATA, *Dimya* **XV 44,** *XV 46*
finalis, Pulleniatina XVI 94
FINLAYI, *Neritopsis XI 103,* **XI 104,** *XI 176*
fischeri, Ampullina XI 99
fischeri, Cythere XIV 148
fischeri, Globularia XI 99
fischeri, Loxoconcha XIV 148
fischeri, Loxocorniculum XIV 146, XIV 152
Fissurella XIX 78
fissurella, Styliolina XVII 48
FISSURELLIDAE *XVII 100*
Fissurina XI 279
lucida XI 279
lucida cf. XI 279, XI 290
marginata XVI 94
marginata lucida XI 279
pellucida XI 279
quadricostulata XI 280
radiata XI 280
sp. A XI 280, XI 290
sp. B XI 280, XVI 94
FISCHERINIDAE *XI 272*
Fissotextularia XVIII 159
Fissurina (Produttine) radiata XI 280
fistula, Phormostichoartus XX 30, XX 32
fiterrei meningoi, Triloculina XI 275, XI 286
Flabellum XI 173
flavum, Cardium XVI 6
flexuosa, Globorotalia XIV 29, XIV 62, XIV 76
flexuosa, Rangia XVII 103
flexus, Momipites XVII 38
flintensis, Chlamys (Aequipecten) XII 143
flintii, Sigmoilopsis XVI 92
Florianella bipolaris XVI 61
floridana, Astarte (Ashtarotha) XVI 167
floridana attenuata, Muricidea XII 105
floridana, Aurila XII 69, XII 78, XIV 143, XIV 150
floridana, Basterotella XVI 158
floridana, Calyptraea XI 165
floridana, Cantharus (Pseudosalpinx) XII 106
floridana, Cibicides XI 294, XI 298
floridana conradi, Muricidea XII 109
floridana, Erycina XIX 108
floridana, Gouldia XVIII 124
floridana libertiensis, Muricidea XII 109
floridana, Muricidea XII 105
floridana, Muricopsis XII 106
floridana, Nearomya XVII 103
floridana, Pleurodesma XVI 161
floridana, Pseudomiltha XVII 103
floridana, Radimella XIV 143
floridana, Rosalina XI 286, XI 294
FLORIDANA, *Rothpletzia* **XVII 51,** *XVII 53*
floridana, Textularia XVIII 159
floridana, Truncatulina XI 294
floridana, Urosalpinx XII 105, XII 133
floridanum, Durhamella XVIII 130
floridanus, Chicoreus XI 86
floridanus, Cibicides XI 88, XVI 92
floridanus, Conus XII 7
floridanus, Discorbis XI 286
floridanus, Periarchus XII 141, XVIII 130
floridensis, Rosalina XVI 94
floridiensis, Paraster XVIII 135
Floridina antiqua XII 141
floridus, Micrantholithus XI 191
florifer, Chicoreus XI 90
Florilus XI 298
atlanticus XVI 92
grateloupi XI 298, XVI 94
flos, Micrantholithus XI 46, XI 49, XI 188, XI 189
fluckigeri, Goniolithus XI 200, XI 228
fluctuata, Globularia XI 99
foliacea, Crepidula XI 166
folioides, Ostrea (Lopha) XIII 190
FORAMINIFERIDA *XI 271, XI 302, XI 306, XIV 90, XIV 103, XV 1, XVI 168, XVIII 3, XVIII 21, XVIII 157, XVIII 160, XIX 92, XIX 181, XIX 185, XIX 188, XX 8*
Fordilla XVI 75
sibirica XVI 76
troyensis XVI 76

formosa, Cyclococcolithina XI 18, XI 24, XI 32, XI 195, XI 230
formosa, Ericsonia XI 195
formosa, Globorotalia XI 11
formosa, Umbilicosphaera XI 24
formosum, Cardium XVI 7
formosum, Eurete XVI 138
formosum, Loxocardium XVI 14, XVI 16
formosus, Cyclococcolithus XI 24, XI 195
formosus, Phacorhabdotus XVII 34
fornicata, Crepidula XVII 101, XIX 61
fornicata, Haplocytheridea XVII 34
fortunatus, Anisoconchus XV 85
forulata, Cytherura XII 64, XIV 142
fossilis, Denticula XX 48
fossilis, Denticulopsis XX 8, XX 48, XX 54
fossilis, Nitzschia XX 54, XX 58
fossilis, Scapholithus XVI 87
fossilis, Thalassiosira XX 62, XX 64
fossulata, Globigerina XVIII 33
foveolata, Bairdia XIV 139
Fragilaria hirosakiensis XX 62
fragile, Brevicardium XVI 6
fragile, Cardium XVI 38
fragile, Trithyrodinium XII 197
fragilis, Brizalina XVI 94
fragilis, Darwinula XIX 146
fragilis, Dimya XV 50
fragilis, Lepidocyclina XII 142
fragilis, Mactra XVII 103
fragilis, Momipites XVII 39
fragilis, Proeuplectella XVI 137
fragilis, Protocardia (Brevicardium) XVI 32
fragilis, Virgulinella XIII 141
fragilis aff., Pseudocythere XII 70, XII 93
fragilis crassiplicata, Dimya XV 50
fragilis miopliocenica, Dimya XV 50
fragilis punctata, Dimya XV 50
fragilis sp. aff., Darwinula XIX 148
FRAGINAE *XIII 172, XVI 11, XVI 20*
Fragum XIII 172, XVI 6
mundum XIII 172
newtoni XVI 5
shepstonense XVI 5
symbolicum XVI 6
TUNICULA *XIII 166, XIII 170,* **XIII 172**
fragum, Cardium XIII 172, XVI 6
Fragum (Fragum) XVI 20
fragum XVI 22, XVI 24
fragum, Fragum (Fragum) XVI 22, XVI 24
Fragum (Lunulicardium) XVI 20
retusum XVI 22, XVI 24
francesae, Typhis XVII 126
frankii, Houstonia XIII 61
franquesi, Paracypris XII 59
franquesi sp. cf., Paracypris XIX 139
fredricksburgensis, Cytherella XII 92
Frigiocardium XVI 6
Fromea XII 216
amphora XII 216, XII 226
FRONDICULA, *Lopha* **XIII 190**
Frondicularia saggitula XVI 94
frons, Lopha XIII 190
frugalis, Distephanus XX 90, XX 94
Fulgoraria mississippiensis XIV 107
FULGORARIINAE *XV 118*
fulgurans, Nerita XVII 131
fulgurans, Nerita (Theliostyla) XVII 132
Fulva XVI 6
aperta XVI 6
fulvescens, Hexaplex XVII 101
funafutiensis, Miliolina XI 274
funafutiensis, Murex XVI 46
funafutiensis, Pygmaepterys XVI 52
funafutiensis, Quinqueloculina XI 274, XI 282
funiculata, Nerita XVII 131
funiculosus, Fusus XIII 196
furcaspiculata, Lithamphora XX 34
furcatolithoides, Sphenolithus XI 48, XI 54, XI 185
furcatus, Discoaster XI 69
furcatus, Marthasterites XI 66, XI 69, XI 72
Fursenkoina XI 296
compressa XI 296, XI 298
mexicana XI 296, XI 298
pontoni XI 296, XVI 94
punctata XVI 94
FURSENKOININAE *XI 296*
fusca, Botula XIX 162, XIX 172
fusca, Miliammina XI 271, XI 280
fusca, Quinqueloculina XI 271
Fuscocardium XVI 6
fuscus, Mytilus XIX 172
fusiformis, Conus XII 25
fusiformis, Murex XIX 81
fusiformis, Muricopsis (Risomurex) XIX 74, XIX 81
fusiformis, Ocinebrina XIX 81
fusiformis suga, Tritonalia (Ocinebrina) XIX 82
fusiformis, Tritonalia XIX 81
fusiformis, Tritonalia (Ocinebrina) XIX 81
Fusilatirus XIII 196
pauli XIII 196
FUSINAE *XIII 196*
fusinoides, Poirieria (Panamurex) XII 103
Fusinus XIII 196
fusta, Nodosaria XVI 94
fusulus, Orania XIX 81, XIX 86
Fusus XIII 196, XVII 17
aciformis XIII 196
bronni XIII 196
cognatus XIII 196
decurrans XI 125
funiculosus XIII 196
mexicanus XII 133, XII 134
muricoides XIX 70, XIX 77

G

gabbi, Cardium XVI 43
gabbi, Orthaulax XV 108
gabbi, Poirieria (Panamurex) XII 103
gabbi, Typhis XVII 128

gabbi, Typhis (Pilsbrytyphis) XVII 128
GADIFORMES *XV 102*
gaillardi, Laevicardium (Trachycardium) XVI 38
galatheae, Neopilina XVI 59
galea, Tonna XVII 101
galbensis, Muricopsis (Risomurex) XIX 70, XIX 83
galbensis, Risomurex XIX 83
galenis, Ellipsoplacolithus XV 13
Galeocerdo XIV 161
Galeodolium XIX 178
galvestonense, Elphidium XI 290
galvestonensis, Elphidium XI 290
Gangamocytheridea plicata XIX 139
gapus, Murex XI 153
GARDNERAE, *Conus* **XII 12,** *XII 14*
gardnerae, Oliva (Omogymna) XVI 116, XVI 119
gardnerae, Olivella XVI 118
gardneri, Polylepidina XI 181
garettii, Quinqueloculina XVI 94
garretti, Buntonia XII 84
garretti, Cythereis XII 84
garretti, Echinocythereis XII 84
Gastrochaena XII 161
cimitariopsis XII 161
cuniformis XII 161
hians XIX 61
mytiloides XII 161
Gastrochaena (Spengleria)
cimitariopsis XII 161
EMILYANA *XII 161,* **XII 162**
rostrata XII 161
Gastrochaenolites XIX 56
GASTROPODA *XI 85, XI 96, XI 99, XI 103, XI 132, XI 163, XI 176, XI 308, XII 1, XII 31, XII 33, XII 44, XII 45, XII 105, XII 133, XIV 105, XV 118, XVI 56, XVI 61, XVI 107, XVI 149, XVII 51, XVII 57, XVII 100, XIX 61, XIX 63, XIX 177*
gatunense, Cardium (Fragum) XVII 56
gatunense, Cardium (Trachycardium) XVII 56
gatunensis, kugleri, Terebra (Strioterebrum) XVIII 61
gatunensis, Murex XI 152
gatunensis, Oliva XVI 108
gatunensis, Poirieria (Panamurex) XII 102
Gaudryina XIX 182
bradyi XIX 186
filiformis XIX 186
pseudofiliformis XIX 186
gelbi, Loxostomum XVI 94
Gemma gemma XVII 104, XVII 112
gemma, Gemma XVII 104, XVII 112
gemmata, Cristellaria XIV 94
gemmata, Symplocos XVII 29
gemmeus, Discoaster XIX 9
gemmifera, Rhaphoneis XX 56, XX 58
Gemmula
hindsiana XVII 123
vaningeni XVII 123
georginensis, Mellopegma XVI 75
Geospiza XVII 19
Gephyrocapsa
caribbeanica XI 80, XI 119, XV 13, XV 28, XVI 146, XIX 131
oceanica XVI 87
reticulata XI 119, XV 16, XV 28, XVIII 26
reticulata sp. cf. XV 5
gerda, Bairdia XIV 139, XIX 132
gerda, Neonesidea XIV 139
gerda sp. cf., Neonesidea XIV 139, XIV 146
GERMAINAE, *Pygmaepterys XVI 48,* **XVI 50**
germinans, Avicennia XII 107
Geukensia demissa granosissima XVII 102
geversianum, Buccinum XII 104, XIV 131
geversianus, Trophon XII 118
gibba, Globulina XVII 35
gibbosa, Amphistegina XVI 94
gibbosa, Crepidula (Janacus) XI 166
gibbosa, Odostomia XVII 102
gibbosa, Plicatula XVII 102
gibbus, Argopecten XVII 102, XIX 61
gibsonensis, Actinocythereis XII 82
gibsoni, Hermanites XVII 34
gigantea, Entopyla XX 50, XX 54
gigantea, Fasciolaria XIII 195, XV 113
gigantea, Lucina XVII 136
gigantea, Pseudomiltha XVII 136
gigarton, Luvula XII 77, XIX 139
GIGARTONOIDES, *Luvula* **XII 76,** *XII 82*
gigas, Chiasmolithus XI 18, XI 19, XI 22
gigas, Coccolithus XI 19
gigas aff., Coccolithus XIX 22
gigas, Modiola XIX 171
gigas, Spongodiscus XX 14
gigas, Strombus XIII 114
gilbertharrisi, Drupa (Morula) XIX 78
gilbertharrisi, Muricopsis (Risomurex) XIX 72, XIX 78
gilbertharrisi, Risomurex XIX 78
gilletteorum, Murex (Panamurex) XI 152
gilletteorum, Poirieria (Panamurex) XI 152
ginella, Trigonopyxidium XVII 37
Gisortia harrisi XII 143
glabra cf., Marginulina XVII 35
glacialis, Podosira XX 56
glacialis, Porosira XX 56, XX 58
glacialis, Spongotrochus XX 14, XX 16
GLADIATOR, *Cancellaria (Sveltia)* **XII 35,** *XII 36*
gladius, Rhabdolithes XI 45
gladius, Rhabdosphaera XI 45
Glandulina laevigata XVI 94
GLANDULINIDAE *XI 279*
glebosum, Agnocardia XVIII 38
glebosum, Cardium XVIII 38
Gleicheniidites senonicus XVII 29
Globanomalina
praepumilio XIV 52
pumilio XVIII 35
Globicuniculus mitra XVIII 34
Globigerapsis
kugleri XI 11
mexicana XI 11
Globigerina XIV 15
aequilateralis XV 12

aequilateralis involuta XV 12
altispira XV 10
apertura XV 10
bilobata XIV 50, XV 10
bradyi XV 13
bulloides XI 119, XIV 15, XIV 16, XV 10, XVI 94
bulloides apertura XV 10, XV 16, XVIII 30, XIX 131
bulloides bulloides XV 10, XV 16, XVI 146, XVIII 24
calida XIV 16, XIV 34, XIV 38, XV 10, XVIII 22
calida praecalida XV 10, XV 16, XVIII 34
conglobata XIV 40, XV 11, XVIII 34
conglobatus conglobatus XVIII 22
crassaformis XVIII 34
crassiformis XIV 60
cristata XVIII 35
daubjergensis XII 176, XIX 13
decoraperta XV 11, XV 16, XVI 145, XVIII 24
digitata XIV 17, XIV 34
druryi decoaperta XV 11
dutertrei XIV 58
elongata XIV 40
eugubina XIX 11
falconensis XIV 17, XIV 34, XVI 94
fistulosa XIV 42
fossulata XVIII 33
glutinata XVIII 22
gortmanii XII 148
hexagona XVIII 34
incisa XVIII 22, XVIII 33
inflata XIV 64
juvenilis XV 11, XV 14
nepenthes XIV 9, XV 11, XV 14, XVI 146, XVIII 22, XVIII 34, XIX 127
pachyderma XIV 18, XIV 35
quadrilobata XIV 44, XV 12
quinqueloba XIV 19, XIV 35
riveroae XV 10
rubescens XIV 19, XIV 36, XVI 85
rubra XIV 46, XV 12
sacculifera XIV 46, XV 12
seminulina XVIII 35
siphonifera XIV 38, XV 12
sp. XIV 20, XIV 38
uvula XV 13
venezuelana XV 13
Globigerina (Subbotina) triloculinoides XII 237
Globigerinatella
calida XVIII 34
insueta XVII 51
Globigerinella XIV 38
calida XVIII 34, XIX 127
siphonifera XIV 20, XIV 38, XIV 44, XV 12
GLOBIGERINIDAE XIV 15
Globigerinita XIV 54
glutinata XIV 54, XIV 62, XVI 94, XVI 145, XVIII 34
humilis XVIII 35
iota XIV 27, XIV 56, XIV 62
parkerae XVIII 35
uvula XIV 27, XIV 56, XIV 62, XV 12, XV 16, XVIII 28
Globigerinoides XIV 40
conglobatus XIV 21, XIV 40, XIV 46, XVI 94
conglobatus conglobatus XV 11, XV 16, XVI 145, XVIII 34
daubjergensis XIX 13
elongatus XIV 21, XIV 40, XIV 48
fistulosus XIV 42, XIV 46
helicina XVI 94
mitra XVIII 24, XVIII 34
obliqua XIV 42, XV 12
obliqua extremus XV 12, XV 18, XVI 145, XVIII 26
obliquus obliquus XIV 42, XV 12, XV 18, XVI 146, XVIII 26
parkerae XVIII 34
pyramidalis XVI 94
quadrilobatus sacculifer XIV 22, XIV 46, XIV 52, XV 12, XV 18, XVI 146, XVIII 30
quadrilobatus quadrilobatus XIV 22, XIV 44, XIV 50, XV 12, XV 18, XVI 145
ruber XIV 23, XIV 46, XIV 52, XV 12, XV 18, XVI 85, XVI 94, XVIII 28
sacculifer XVI 94
tenellus XIV 23, XIV 48
trilobus XVI 94
Globocardium XVI 7
Globoconusa daubjergensis XIX 11
Globoquadrina XIV 56
acostaensis XV 10
altispira XIV 9
altispira altispira XV 10, XV 18, XVI 145, XVIII 26
altispira globosa XV 10, XV 18, XVIII 26
conglomerata XV 11, XV 18
dutertrei XIV 28, XIV 58, XIV 64
hexagona XVIII 34
humerosa XV 10
venezuelana XIV 9, XV 13, XV 20, XVIII 26
Globorotalia XIV 60
acostaensis XV 10
AKERSI XI 302, *XI 304, XIV 32, XIV 66, XIV 78*
angulata XIX 11
aragonensis XI 11
compressa XII 176, XVII 35, XIX 11
conomiozea XV 11
crassacrotonensis XV 11
crassaformis XVI 86, XVIII 34
crassiformis XIV 29, XIV 60, XIV 70
fimbriata XVI 94
flexuosa XIV 29, XIV 62, XIV 76
formosa XI 11
hirsuta XIV 30, XIV 62, XIV 72, XVI 94
humerosa XV 10
inconstans XIX 11
inflata XI 119, XIV 30, XIV 64, XIV 72
lehneri XI 11
margaritae XV 11, XIX 130
menardii XI 302, XIV 31, XIV 64, XIV 74, XVI 84, XVI 94
menardii miocenica XVIII 34
menardii multicamerata XV 11

multicamerata XIV 9
multiloculata XI 306
pseudobulloides XIX 11
pseudomenardii XIX 11
pseudomiocenica XV 11
pusilla XIX 11
scitula XIV 31
spiralis XIX 11
triloculinoides XIX 11
trinidadensis XIX 11
truncatulinoides XI 80, XIV 32, XIV 66, XIV 76, XVI 85, XVI 94
tumida XIV 33, XIV 68, XIV 76, XVI 85, XVI 94
uncinata XIX 11
ungulata XI 302, XIV 33, XIV 68, XIV 78, XVI 85, XVI 94
velascoensis XIX 11
Globorotalia (Globorotalia)
crassula conomiozea XV 11, XV 20
cultrata limbata XV 11, XV 20
cultrata menardii XV 11, XV 20, XVI 145
margaritae XV 11, XV 20, XVI 145
miocenica XVI 146
multicamerata XVI 146
multicamerata cf. XV 11, XV 20
Globorotalia (Menardiella)
cultrata limbata XVIII 26
miocenica XVIII 24, XVIII 34
Globorotalia (Obandyella)
margaritae XVIII 26
scitula XVIII 28
Globorotalia (Truncorotalia)
crassaformis XVIII 34
crassiformis XVIII 24
Globorotalia (Turborotalia)
acostaensis acostaensis XV 10, XV 20, XVI 145
acostaensis humerosa XV 10, XV 22, XVI 146
acostaensis pseudopima XV 10, XV 22, XIX 130
centralis XII 148
incisa XVIII 33
scitula scitula XV 12
GLOBOROTALIIDAE *XIV 60*
Globorotaloides
hexagona XIX 127
hexagona hexagona XVIII 24, XVIII 34
globosa, Labrapollis XVII 39
globosum, Cardium XVIII 38
globosum, Cardium (Trachycardium) XVIII 38
globosus, Cassidulus XVIII 138
globosus, Murex XVI 97
globosus, Sphaerogypsina XVI 94
Globularia
fischeri XI 99
fluctuata XI 99
sigaretina XI 99
globulifera, Ramulina XVI 94
Globulina
australis XI 279
gibba XVII 35
rotundata XVII 35
sp. XVI 94
glutinata, Globigerina XVIII 22
glutinata, Globigerinita XIV 54, XIV 62, XVI 94, XVI 145, XVIII 34
Glycimeris XVIII 166
subcrenata XVIII 68
glycimeris, Mya XVIII 166
Glycymerella XVIII 67
GLYCYMERIDIDAE *XVIII 68*
Glycymeris XII 143, XVIII 67, XVIII 71, XVIII 73, XVIII 166
cookei XVIII 73
greenensis XVIII 68
intercostata XVIII 73
lamyi tampae XII 143
multicostata XVIII 73
subcrenata XVIII 68
subgyrata XVIII 68
tampae XII 143
undata XIX 61
wordeni XVIII 68
Glyphodesmus XX 50
williamsonii XX 50, XX 54
Glyphodiscus XX 50
stellatus XX 50, XX 54
Glyptodon XVII 4
Gnathodon XII 243
cuneatus XII 247
gochtii, Korystocysta XVIII 154
goesii, Bolivina XI 282
goldfussi, Panopea XVIII 165
gomillionensis, Actinocythereis XII 81, XII 86, XIX 138
gomillionensis, Cythereis XII 81
gomillionensis sp. cf., Actinocythereis XIX 138
gomillionensis, Trachyleberis XII 81
Gongylis XI 246
salzwedelensia XI 244, XI 246
GONIOLITHACEAE *XI 200*
Goniolithon XIII 128
Goniolithus XI 200
fluckigeri XI 200, XI 228
goniostoma, Cancellaria XII 40
GONYAULACACEAE *XII 181*
Gonyaulacysta XII 185
orthoceras XII 185, XII 202
wetzelii XII 186, XII 202, XII 204
Gonyaulax
orthoceras XII 186
wetzelii XII 186
goreaui, Basiliomya XV 34
gorgasiana, Fasciolaria XV 114
gortmanii, Globigerina XII 148
Gothanipollis XVII 27
cockfieldensis XVII 29
Gouldia XVIII 123
bermudensis XVIII 124
cerina XVIII 124
floridana XVIII 124
Gouldia (Gouldia) cerina XVIII 123
Gouldia **(PARAGOULDIA) PLATYCOSTATA XVIII 123,** *XVIII 125*
gouldii, Rhyncholampas XVIII 73, XVIII 130
gracile, Cordosphaeridium XVII 30
Gracilimurex [see also Dermomurex (Gracilimurex)] XI 129, XI 141

gracilis, Balcis XVII 101
gracilis, Sabbatia XIII 61
gracilis, Triloculina XI 275
gracilis, Vaginulina XVII 35
graciosa, Cytheridea XIX 152
gradata, Oliva (Omogymna) XVI 114
gramineoides, Graminidites XVII 29
Graminidites XVII 27
  gramineoides XVII 29
Grammatodon XVIII 71
Grammatophora XX 50
  angulosa XX 50, XX 54
  merletta XX 50, XX 54
grammatus, Modiolus (Brachydontes) XIX 162
grammatus curtulus, Modiolus (Brachydontes) XIX 161
granatina, Basterotia XVI 161
Grandaxinaea XVIII 72
grande, Lychnocanium XX 24
grande, Lychnocanoma XX 24
grandis, Chiasmolithus XI 19, XI 26, XI 193, XI 244
grandis, Coccolithus XI 19, XI 193
grandis, Dimya XV 40, XV 42
grandis divaricata, Dimya XV 42
grandis, Plagiobrissus XVIII 134
granifera, Trigoniocardia (Trigoniocardia) XVI 22, XVI 24
graniferum, Cardium XIII 177, XVI 8
granilabratus cf., Casuarinidites XVII 29
Granocardium XVI 7
Granocardium (Granocardium) XVI 18
  carolinum XVI 16
  proboscidium XVI 14
Granocardium (Ethmocardium) XVI 18
  whitei XVI 14
Granocardium (Criocardium) XVI 18
  dumosum XVI 14, XVI 16
granosa, Cristellaria XIV 94
granosa, Hystrichosphaera XII 190
granosus, Spiniferites XII 190
granulata, Acanthochiton XVI 63
granulatum, Phalium XVII 101
granulatus, Araliaceoipollenites XVII 29
granulatus, Conus XII 32
granulifera, Deflandrea XII 192, XII 200
granulosa, Plagiocardium (Plagiocardium) XVI 14
granulosum, Cardium XVI 8
grata, Spiroloculina XI 273
grata angulata, Spiroloculina XI 273
grateloupi, Florilus XI 298, XVI 94
grateloupi, Nonion XI 298
grateloupi, Nonionina XI 298, XVIII 160
gratiosum, Cardium XVI 38
gratus, Nannippus XI 112
grata, Turbinella XVIII 50
gratus, Xancus XVIII 52
gravida, Thalassiosira XX 64
grayi, Clementia (Egesta) XI 101
grayi, Endopachys XI 173
greenensis, Glycymeris XVIII 68
greenhornensis, Rotalipora XI 306
greensboroensis, Calyptraea XI 166
Gregariella XIX 168
  ARCAFORMA *XIX 162*, **XIX 168**
  coarctata XIX 169
  coralliophaga XIX 169
GREIGI, *Voorthuyseniella* **XIV 88**
griphus, Nemocardium XVI 5
griphus, Nemocardium (Arctopratulum) XVI 28, XVI 34
groenlandicum, Cardium XVI 8
groenlandicus, Serripes XVI 36, XVI 38
grossmani, Cytherella XII 93
grus, Timoclea XVII 104
Gryphaea vesicularis XII 236
Gryphaeostrea pulaskensis XVII 33
guasarensis, Cytherella XII 93
Guettardiscyphia XVI 138
guildingi, Lyria (Enaeta) XVI 120
gunteri, Elphidium XVI 94
gunteri galvestonense, Elphidium XI 290, XI 296
gunteri galvestonensis, Elphidium XI 290
gunteri, Nucinella XVIII 162
gunteri, Pleurodon XVIII 162
gunteri, Virgulina XIII 140
guppyi, Pachycrommium XV 110
gurabicum, Vasum XV 112
guttata, Lenticulina XIV 94
guttata, Voluta XIV 120
gutticostatus, Robulus XIV 85
Guttulae XVI 82
Guttulina XI 279
  australis XI 279
  laevis XI 279, XI 290
  problema XVII 35
  sp. XVII 35
  spicaeformis XVI 94
GYMNODINIACEAE *XII 180*
GYMNODINIALES *XII 180*
Gymnodinium
  filum XII 181
  heterocostatus XII 181
  westralium XII 181
Gyroidina XIX 182
  soldanii XV 6
  subangulata XVII 35

H

Habecardium XVI 7
Hadriania (Hexachorda) tenella XI 128
hadropleura cf., Hermanites XVII 34
HADROS, *Ophiraphidites* **XVI 127,** *XVI 128, XVI 134*
haemastoma canaliculata, Thais XVII 101
haemastoma floridana, Thais XVII 101
haitense, Cardium XIII 177
haitense, Vasum XV 112
haitensis, Ostrea XV 44, XVI 97, XVI 159
haitensis, Pseudomiltha XVII 135
haldemani, Oligopygus XVIII 128, XVIII 131

haleanus, Athleta XV 73
Halimeda XIII 116
halionyx, Actinoptychus XX 41, XX 46
Halitherium XIV 161
HAMANI, *Bolivina (Brizalina)* **XIV 168**
HAMANI *aliformis, Bolivina (Brizalina) XVI 168*
HAMANI HAMANI, *Bolivina (Brizalina)* **XVI 168**
HAMANI *horizontalis, Bolivina (Brizalina) XVI 168*
hamatum, Cytheropteron XII 64, XII 74
hamatum sp. aff., Cytheropteron XIX 139
hamulatum, Lycopodium XVII 29
Hankenina XVIII 73
hannai, Buccella XVI 94
hannai, Calocyclas XX 28
hannai sp. aff., Cytherella XIX 138
hannai, Lamprocyrtis XX 28
hanseni, Lenticulina XIV 94
Hantkenina XII 143
alabamensis XII 148
aragonensis XI 11
hanzawae, Stephanogonia XX 60
Hanzawaia XI 300, XIX 182
concentrica XVI 92
strattoni XI 300, XVI 94
Haplocytheridea XIV 140, XIX 139
bradyi XIV 140, XIV 146
bradyi cf. XII 70, XII 93
fornicata XVII 34
macrolaccus munseyi XVII 34
proboscidiala XIV 140
setipunctata XIV 140, XIV 146
wadei XIV 140
Haplophragmoides XI 271
canariensis XI 271
HAPLOPHRAGMOIDINAE *XI 271*
HAPTOPHYCEAE *XI 12, XI 187*
haraldi, Turbo XI 168
harlani, Mylodon XV 59
harlani, Olenothyris XII 236
Harlea XVI 160
harpago, Cytherella XII 92
harpago cf., Cytherella XII 92, XII 97
Harpella XIV 113
Harpeola XIV 113
Harpa XVIII 56
americana XVI 155, XVI 156, XVII 57, XVIII 54, XVIII 56
americana cf. XVII 57, XVIII 56
crenata XVIII 54, XVIII 58, XVIII 59
crenata cf. XVIII 59
doris XVIII 54
ISTHMICA *XVIII 54,* **XVIII 57**
myrmia XVII 57, XVII 58, XVIII 56
nobilis XVIII 56
rosea XVI 155, XVIII 56
harpa, Buccinum XVIII 56
harpa, Voluta XIV 114
HARPIDAE *XVIII 56*
harrimani, Laevicardium (Profulvia) XVI 38
harrimani, Papyridea XVI 8
harrisi, Gisortia XII 143
harrisi, Lyrichapa XV 118, XV 120
harrisi, Pyrazisinus XI 154
Hassbergia XVI 7
hastata, Bolivina XI 282
Hastigerina XIV 50
aequilateralis XVI 94
pelagica XIV 25, XIV 50, XIV 58
siphonifera XVI 94
Hastigerina (Hastigerina)
siphonifera XV 12, XVIII 26
siphonifera siphonifera XV 12, XV 22, XVI 146
hastula, Aspella XI 132, XI 134
Hastula XVIII 65
salleana XVII 102
hatchetigbeense, Cardium XVI 8
hatchetigbeensis, Acanthocardia (Schedocardia) XVI 14
haueri, Cardium XVI 41
Hauerina XI 277
bradyi XI 277, XI 288
occidentalis XI 277, XI 288
ornatissima XI 277
speciosa XI 277
hayamii, Protocardia (Yokoyamaina) XVI 32
hayamii, Yokoyamaina XVI 8
Hayella situliformis XI 9, XI 186
hayi, Blackites XI 236
hayi, Bukryaster XII 168
hayi, Cepekiella XI 236
hayi, Discoaster XII 166
HAYNESPONGIA XVI 138
VOKESAE *XVI 134,* **XVI 140**
hazeli, Opimocythere XVII 34
Hazelina sp. A XVII 34
hebetata, Rhizosolenia XX 58
Hedecardium XVI 7
heilprini, Lyria XIV 110
heilprini, Lyria (Harpeola) XIV 114, XIV 118
heilprini, Mitra XIX 96
heilprini, Poirieria (Panamurex) XII 102
heilprini tampaensis, Lyria XIV 114
HELCIONELLACEA *XVI 69*
helenae sp. aff., Loxoconcha XIX 139
helianthus, Discoaster XIX 9
Helianthus occidentalis XIII 26
helicina, Globigerinoides XVI 94
Helicopontosphaera XI 39
compacta XI 11, XI 212, XI 234
dinesenii XI 214
kamptneri XI 39, XI 119, XI 210, XV 13, XV 28, XVI 87, XVIII 32
lophata XI 36, XI 40, XI 212, XI 216
reticulata XI 214, XI 234
rhomboidalis XI 212
salebrosa XI 214
sellii XVI 146, XVIII 29, XVIII 35
seminulum XI 36, XI 39, XI 42, XI 214, XI 234
seminulum lophata XI 40
sp. XV 5
sp. A XI 218, XI 234
wilcoxoni XI 216, XI 234
Helicosphaera

carteri XV 13
compacta XI 212
lophata XI 214
reticulata XI 214
seminulum XI 39, XI 40, XI 212, XI 214
seminulum lophata XI 40, XI 212
Heliodiscoaster
barbadiensis XI 199
Heliolithus
kleinpelli XIX 8
riedeli XIX 9
Heliorthus
concinnus XIX 30, XIX 40
denticulatus XIX 30, XIX 42
fallax XIX 30
tenuis XI 195, XIX 24
heliozoides, Stylodicta XX 16
helis, Coccolithus XIX 26
Hemiaulus XX 50
polymorphus XX 50, XX 56
Hemicardia XVI 7
Hemicardium XVI 7
Hemicristellaria sumatrica XIV 94
Hemicyprideis cagigalensis XIX 152
Hemicythere XII 141, XVIII 73
amygdala XIV 143
confragosa XIV 144
HEMICYTHERIDAE *XII 69, XIV 143*
HEMICYTHERINAE *XII 69, XIV 143*
Hemicytherura XIV 142
sablensis XII 78, XII 93, XIV 142
VOKESAE XIV 142, *XIV 148*
Hemidiscors XVI 7
Hemidiscus XX 50
cuneiformis XX 50, XX 56
simplicissimus XX 50, XX 56
HEMIDONACINAE *XVI 11, XVI 20*
Hemidonax XVI 7, XVI 20
donaciformis XVI 22
Hemirobulina XIV 88
HEMISPHAERAMMINIDAE *XVIII 157*
HEMISPHAERAMMININAE *XVIII 157*
henbesti, Palmula XII 148
henkeri, Torcula XII 142
Henryhowella XII 84, XVI 86
asperrima XII 84
asperrima ex. gr. XII 84, XII 90, XIX 139
echinata XII 85
evax XII 84
Heraultipegma XVI 74
varensalense XVI 75
herbstii, Panopeus XVII 114
Hercotheca XX 52
mamillaris XX 52, XX 56
heredium, Cardium XIII 177
Herion XIV 88
HERMANI, *Turbinella XVIII 48,* **XVIII 51**
Hermanites
gibsoni XVII 34
hadropleura cf. XVII 34
midwayensis XVII 34
plusculmensis aff. XVII 34
hernandoensis, Orthaulax XV 112
HERPETOCYPRIDIDAE *XIX 148*
herronii, Euphorbia XIII 18
Hertleinella XII 105
leucostephes XII 105
hertleini, Basterotia (Basterotella) XVI 159
Heterocibicides XIV 103
disjuncta XIV 103
irregularis XIV 103
heterocostatus, Gymnodinium XII 181
Heterocypris XIX 147
sp. XIX 147, XIX 148
heteromorphus, Sphenolithus XI 54, XI 236
hetrophylla, Bollis XIII 61
heteroporos, Lamprocyclas XX 28
heteroporos, Lamprocyrtis XX 28
Heteroraphidites XVI 125
Heterostegina XI 292
depressa XI 294
Heterillina XVIII 10
Hexachorda XI 133
Hexacontium XX 13
spp. XX 13, XX 14
HEXACTINELLIDA *XVI 136*
HEXACTINOSA *XVI 138*
hexagona, Globigerina XVIII 34
hexagona, Globoquadrina XVIII 34
hexagona, Globorotaloides XIX 127
hexagona hexagona, Globorotaloides XVIII 24, XVIII 34
hexagona, Mesocena XX 94, XX 100
hexagona, Oolina XVI 94
hexagonus, Murex XII 104
hexalitha, Mesocena XX 94
Hexaplex XI 156
fulvescens XVII 101
veatchi XI 154
HEXASTEROPHORA *XVI 138*
hians, Gastrochaena XIX 61
HIATELLIDAE *XVIII 166*
hiatus, Cardium (Papyridea) XIII 165
hiculum, Cardium XVI 38
hiemalis, Rhizosolenia XX 58, XX 60
hillae, Reticulofenestra XI 197, XI 228
hillana, Protocardia (Protocardia) XVI 30, XVI 32
hillanum, Cardium XVI 8
Himantidium williamsonii XX 50
hindsiana, Gemmula XVII 123
Hiparion XI 111, XVII 72
Hippocrateaceaedites XVII 27
sp. XVII 29
HIPPONICIDAE *XVII 51*
hirosakiensis, Coscinodiscus XX 44, XX 50
hirosakiensis, Fragilaria XX 62
hirosakiensis, Thalassionema XX 62
hirsuta, Globorotalia XIV 30, XIV 62, XIV 72, XVI 94
hirsuta, Rotalina XIV 62
hirsuta var., Marginulina XV 6
hirsutum, Trichodinium XII 191, XII 208
hirundinus, Discoaster XI 60, XI 199
hirundo, Pterocorys XX 22
hispida, Nodosaria XV 6

hispida, Uvigerina XVIII 32
hispidula, Lagena XVI 94
histrix, Syracosphaera XVI 87
hockleyensis, Textularia XII 140
hodgei, Sconsia XVI 97
Hoeglundina elegans XVI 92
HOERLAE, *Petricola (Petricoxenica)* **XII 163,** *XII 164*
hoerlei, Turbinella XVIII 48, XVIII 50
HOERLEORUM, *Acrosterigma (Vasticardium) XIII 154,* **XIII 162,** *XIII 182*
hohnensis, Marthasterites XI 69
hohnensis, Trochoasterites XI 69
HOLECTYPOIDA *XVIII 130*
Holkopollenites
chemardensis XVII 39
chemardensis cf. XVII 36
sp. C XVII 39
HOLOCENTRIDAE *XV 103*
Holodiscolithus XI 240
solidus XI 240, XI 242
Holoporella spp. XIX 108
Homalocantha XVI 47
homomorphum cf., Apectodinium XVII 37
Honeoyea sp. XVII 48
hoppoensis, Robulus XIV 94
hormoidesi, Podosira XX 56
HORMOSINIDAE *XI 271*
HORMOSININAE *XI 271*
hornelli, Cardium XIII 164
horridus, Stephanopyxis XX 60
Houstonia frankii XIII 61
howei, Cytheretta XII 89
howei, Pellucistoma XII 78
howelli, Cibicides XVII 35
huberti, Muricopsis XIX 86
hudsonense, Cardium XVI 38
Hulingsina XII 62, XIV 141, XVI 86
ashermani XII 62, XII 70, XIV 141, XIV 148
semicircularis XIX 139
spp. XIX 139
tuberculata XII 62, XII 70
humerosa, Globoquadrina XV 10
humerosa, Globorotalia XV 10
humerosa, Neogloboquadrina XVIII 26
humilis, Globigerinita XVIII 35
humilis, Truncatulina XVIII 35
humilis, Turborotalita XVIII 26, XVIII 35
hungarica, Ephedra XVII 28
hungaricum, Cardium XVI 41
HUNTERAE, *Plicatula XI 106,* **XI 108,** *XVI 98*
hustedtii, Denticula XX 48
hustedtii, Denticulopsis XX 48, XX 54
hutchisoni, Calotrophon XII 103
hutchisoni, Poirieria (Panamurex) XII 103, XII 112
huxleyi, Emiliania XI 120, XVI 85
hyalina, Denticula XX 48
hyalina, Denticulopsis XX 48, XX 54
hyalina, Thalassiosira XX 62, XX 64
hyalinopsis, Thalassiosira XX 62, XX 64
hyalinus, Coscinodiscus XX 64
hyalodermum, Veryhachium XVII 37
Hydrodamilis XIV 162
Hydromylina XIV 88
Hyella XVII 110
Hymeniastrum XX 13
spp. XX 13, XX 16
Hyracotherium XV 82
Hystrichokolpoma XII 186
ferox XII 186, XII 204
fimbriata XII 187, XII 204
unispinum XII 187, XII 204
Hystrichosphaera
granosa XII 190
ramosa XII 189
ramosa granosa XII 190
Hystrichosphaeridium XII 187
centrocarpum XII 189
colligerum XII 184
deanei XII 187, XII 204, XII 206
ferox XII 186
placacanthum XII 228
sp. XVII 42
stellatum XII 185
tubiferum XII 188, XII 206, XVII 37
hystrix, Cardium XVI 6

I

Idonearca XVIII 71
Ilex spp. XVII 28
ilosvayi, Cytheridella XIX 154
ilvensis, Actiniscus XI 199
ILYOCYPRIDIDAE *XIX 148*
Ilyocypris XIX 148
sp. XIX 148
imbricatum, Caecum XVII 100
imbricatus, Murex (Chicoreus) XI 90
impactus, Mytilus XIX 165
Impagidinium sp. XVII 37
imperforata cf., Thoracosphaera XIX 44
impressa, Odostomia XVII 102, XVII 105, XVII 109, XVII 112
imprimata, Spiroloculina XVIII 16
imprimatus, **NEAGUITES** *XVIII 16*
inaequalis, Pomatodelphis XVII 71
inamoenus, Quercoidites XVII 29
Incacardium XVI 7, XVI 18
mellisum XVI 16
incerta, Milfordia XVII 39
incertae, Chlamys (Lyropecten) XII 141, XVIII 73
INCERTAE SEDIS *XI 298, XI 300, XIX 44*
incertum, Elphidium XVI 94
incertum mexicanum, Elphidium XI 292
incisa, Actinoptychus XX 41, XX 46
incisa, Globigerina XVIII 22, XVIII 33
incisa, Globorotalia (Turborotalia) XVIII 33
INCOMPERTA, *Lyria (Lyria)* **XIV 112,** *XIV 118*
incompertus, Blackites XI 228
incompta, Attiliosa XII 116, XII 134, XIV 132
incompta, Coralliophila XII 111, XII 134
inconspicuum, Acrosterigma XIII 162

inconspicuum, Cardium XIII 154
inconspicuum, Cardium (Trachycardium) XIII 162
inconstans, Globorotalia XIX 11
incrassata, Oliva XVI 107
incretus, Coscinodiscus XX 46, XX 54
indenta martinensis, Turritella XII 137
indentatus, Dermomurex XI 129, XII 45
indicum, Cardium XVI 38
INEDITA, *Lyria (Lyria)* **XIV 108,** *XIV 122*
indocayapum, Strioterebrum XVIII 61
inepta, Marginella XI 308
inepta, Volvarina XI 308
inermis, Murex XI 148
inexpectata, Pterygocythereis XIX 139
inezana, Plicatula XI 108
infans, Ergalatax XIX 86
infans, Murex XIX 86
inflata, Globigerina XIV 64
inflata, Globorotalia XI 119, XIV 30, XIV 64, XIV 72
inflata, Modiola XIX 171
inflata, Rhabdosphaera XV 124
inflata, Turborotalia XVI 84, XVI 94
inflatum, Eudolium XIX 178
inflatus, Mytilus XIX 171
inflatus, Modiolus XIX 171
infracarinata, Solariorbis XVII 100
infrequens, Betula XVII 39
infrons, Dermomurex (Takia) XI 149, XI 150
INFULATUS, *Conus XII 26,* **XII 28**
infundibuliformis, Ophiraphidites XVI 125, XVI 126, XVI 130
Infundibulum perarmatum XI 164
infusoriodes, Palaeohystrichophora XVII 42
ingens, Actinocyclus XX 41, XX 44
ingens, Eupatagus XVIII 130
ingenuum, Nannippus XI 111
inglisiana, Plectofrondicularia XII 141
Inia XVII 72
Inoceramus XII 166
inodes, Cordosphaeridinium XVII 37
inornatus, Orthaulax XV 108
insculpta, Crepidula (Crepipatella) XI 168
insignis, Triloculina XVI 94
instructa, Tilia XVII 28
insueta, Globigerinatella XVII 51
Insulapollenites rugulatus XVII 30
Integricardium XVI 7
intapurpurea, Chione XVII 104, XIX 61
Integricardium (Integricardium) XVI 20
dupinianum XVI 30, XVI 32
Integricardium (Onestia) XVI 20
onestae XVI 30
intercisus, Deflandrius XIX 36
intercisus, Rhabdolithus XIX 36
intercisus, Zygrhablithus XIX 36
intercostata, Glycymeris XVIII 73
intermedia, Corvina XV 100, XV 103
intermedia, Fasciolaria XV 113
intermedius, Murex XI 122, XIX 65
intermedius, Otolithus (Sciaenidarum) XV 100
internostriatum, Dimya XV 50
Interpollis
paleocenica XVII 39
supplingensis XVII 36
Interporopollenites turgidus XVII 39
interrasilis, Opimocythere XVII 34
interrogatorium, Laevicardium XVI 38
interrupta, Turbonilla XVII 102
Intratripollenites stavensis XVII 28
intusradiatum, Dimyodon XV 51
intusstriata, Deuteromya XV 50
intusstriata, Dimya XV 50
intustriata, Dimya XV 50
inusitata, Lagena XVI 94
inusitatus, Lenticulina XIV 85
INUSITATUS, NEAGUITES *XVIII 10,* **XVIII 15**
Inversidinium XII 218
CAUDATUM XII 218, *XII 222*
exilimurum XII 218
inversus, Markalius XI 196, XI 228, XVII 31, XIX 28
inversus, Cyclococcolithus XI 196
involutus, Fasciculithus XIX 9
involutus, Pseudovacuopollis XVII 36
involvens, Cyclogyra XI 273, XI 280
involvens, Operculina XI 273
io, Cibicidoides XVI 94
iostoma, Murex XIX 86
iostomus, Murex XIX 86
iota, Globigerinita XIV 27, XIV 56, XIV 62
iotus, Lenticulina XVI 94
iranjanense, Cardium (Cerastoderma, Parvicardium) XVI 38
iris, Tellina XVII 103
irradians concentricus, Argopecten XVII 102
IRREGULARE, *Dichadogonyaulax XVIII 150,* **XVIII 154**
irregularis, Bigenerina XI 272
irregularis, Braarudosphaera XI 188, XI 212
irregularis, Heterocibicides XIV 103
irregularis, Voorthuyseniella XII 145, XII 157
irrorata, Littorina XVII 100
Isabelidinium
acuminata XVII 28
cooksoniae XVII 43
isabellae, Caricella XIV 115
isabellae, Enaeta XIV 115
isabellae, Lyria (Enaeta) XIV 115, XIV 120
ischna, Strioterebrum XVIII 65
Ishnochiton sp. XIII 114
islacolonis, Aphera XV 106
isocardia, Cardium XIII 154, XVI 8, XVII 55, XVIII 37
isocardia, Trachycardium XVII 103
isocardia, Trachycardium (Trachycardium) XVI 20
Isognomon XIX 161
Isophyllastrea rigida XIII 118
Isophyllia sinuosa XIII 116
isomitratus, Conus XII 8, XII 10
isomitratus sulculus, Conus XII 8
Ispidula XVI 107
ispidula, Voluta XVI 107

ISTHMICA, *Harpa XVIII 54,* **XVIII 57**
Isthmolithus
claviformus XI 244
recurvus XI 11
Isurus XIV 161

J

jacksonensis, Massilina XVIII 12
jacksonensis, Miliola XVIII 3, XVIII 8
jacksonensis, Operculinoides XII 141
jacksonensis punctatocostata, Massilina XVIII 12
jacksonensis, **TAPPANELLA** *XVIII 10, XVIII 12*
jaliscoensis, Muricopsis XIX 86
jamaicensis, Balcis XVII 101
jamaicensis, Mytilopsis XVIII 165
jani, Dermomurex (Trialatella) XI 144, XI 146
jani, Murex XI 146
Jania crassicosta XIX 84
Janiopsis crassicosta XIX 84
janischii, Coscinodiscus XX 44
japonica, Dimya XV 50
japonicum, Endopachys XI 173
japonicum, Rhabdonema XX 56
jaspidea, Olivella XVI 119
jaspidea, Voluta XVI 119
Jaspidella XVI 119
cofacorys XVI 116, XVI 119
liveoakensis XVI 119
santidominici XVI 120
jaspideus, Conus XII 7
jaspideus stearnsi, Conus XIX 61
jeffersonius, Pecten XVI 98
Jefitcha claybornensis XV 100, XV 103
jimlingii, Distephanus XX 90, XX 96
johnsoni, Caecum XVII 100
johnsoni, Cytherura XII 63
johnsoni, Ostrea XI 181
johnsoni, Weisbordella XVIII 130
johnsoni cf., Megacythere XII 93, XII 97
johnsonoides, Cytherura XII 63
jonei, Cricolithus XVI 87
Jonesia XII 60, XII 76
simplex XII 60
simplex cf. XII 60, XII 70
jouseana, Synedra XX 62
jouseae, Nitzschia XX 54, XX 58
jugata, Birkelundia XI 12, XI 22, XI 194
jugatus, Tremalithus XI 12
Juglans nigripites XVII 28
junonia, Scaphella XVII 101
Jurassicardium XVI 7, XVI 20
axonense XVI 30, XVI 32
juvenilis, Globigerina XV 11, XV 14

K

kaesleri, Paracypris XII 59
kaiparaensis, Dimya XV 50
kamptneri, Helicopontosphaera XI 39, XI 119, XI 210, XV 13, XV 28, XVI 87, XVIII 32
kamtschatica, Denticula XX 48
kamtschatica, Denticulopsis XX 8, XX 48, XX 54
Kangarina ancyla XIX 139
kansasense, Cardium XVI 8
karlana, Protocytheretta XII 86, XII 88, XII 90
karlani, Cytheretta XII 86
karlani, Paracytheretta XII 86
Karreriellla XIX 185
bradyi XIX 186
OBTURACULOIDES XIX 185, *XIX 186*
Kathocardium XVI 7
kedvesii, Cyrillaceaepollenites XVII 29
keenae, Typhis XVII 128
Keenaea XVI 7
Keenocardium XVI 7
kempi, Fasciolaria XV 108, XV 113
kentuckyensis, Rhytiodentalium XVI 79
kettonense, Korystocysta XVIII 154
kettonensis, Korystocysta XVIII 148
kiktenkoi, Cerastoderma XVI 7
kittonii, Aulacodiscus XX 42, XX 48
kleinpelli, Heliolithus XIX 8
Koczyia XI 34
excelsa XI 34, XI 210
fimbriata XI 220
lepida XI 34
wechesensis XI 32, XI 34, XI 36, XI 210
kollmanni, Cytheridea XIX 146
Korobkoviella XVI 7
Korystocysta XVIII 154
gochtii XVIII 154
kettonense XVIII 154
kettonensis XVIII 148
norrisii XVIII 154
pachyderma XVIII 148
krempii, Ulmipollenites XVII 39
Krithe XII 60, XVI 86
bartonensis XII 61
cubensis XII 61
dolichodeira XII 61
markhoveni XII 61
perattica XVII 34
producta XII 60
producta cf. XII 60, XII 74
reversa XII 61
trinidadensis XIX 139
vicksburgensis XII 61
KRITHINAE *XII 60*
kruschii, Nyssa XVII 29
KRUTAKI, *Purinana* **XII 70,** *XII 78*
kuepperi, Discoaster XI 69
kuepperi, Discoasteroides XI 66, XI 69, XI 72
kugleri, Cribroelphidium XI 292, XI 298
kugleri, Globigerapsis XI 11
kugleri, Terebra XVIII 61

kurodai, Favartia XVI 47
Kurtziella
atrostyla XVII 102
serga XVII 102
kurzii, Coscinodiscus XX 44, XX 50

L

labiosa, Miliolinella XI 276, XI 288, XVI 94
labiosa, Triloculina XI 276
Labrapollis
globosa XVII 39
sp. XVII 36
laccapoia, Poirieria (Panamurex) XI 83, XI 152, XII 104
lacera, Dossetia XX 48, XX 54
lacera, Xanthiopyxis XX 48
lacerta, Robulus XIV 94
lactea, Candona XII 59
lacunosa, Pseudoemiliania XI 120, XV 13, XV 28, XVI 146, XIX 130
lacunosus, Ellipsoplacolithus XV 13
LACUSTRIS, *Ammopemphix* **XVIII 157**, *XVIII 158*
laesareolatus, Coscinodiscus XX 44, XX 50
laeve, Vermiculum XI 279
LAEVICARDIINAE *XIII 184, XVI 14, XVI 22*
Laevicardium XIII 184, XVI 7
compressum XIII 174, XIII 178, XIII 185
interrogatorium XVI 38
laevigatum XIII 184, XVII 103
nemo XVI 38
oblongum XIII 184
onestae XVI 7
pictum XIX 61
soyeri XVI 38
tertium XVI 38
Laevicardium (Dinocardium) XVI 22
robustum XVI 36
Laevicardium (Fulvia) XVI 22
apertum XVI 36
Laevicardium (Laevicardium) XVI 22
oblongum XVI 36, XVI 38
Laevicardium (Profulvia) XVI 22
harrimani XVI 38
Laevicardum (Trachycardium)
couvrili XVI 36
gaillardi XVI 38
senticosum XVI 40
thielei XVI 38
Laevicardium (Trachycardium, Acrosterigma)
enode XVI 38
leucostomum XVI 36
Laevicardium (Vepricardium) rudentis XVI 38
laevigata, Glandulina XVI 94
laevigata, Nodosaria (Glandulina) XI 279
laevigata, Sconsia XVII 124
laevigata, Turbinella XVIII 47
laevigatum, Laevicardium XIII 184, XVII 103
laevis, Guttulina XI 279, XI 290
laevis, Lagena XI 279, XI 290, XVI 94
laevis, Uvigerina XI 284
Lagena XI 279, XIX 182
hispidula XVI 94
inusitata XVI 94
laevis XI 279, XI 290, XVI 94
quadricostulata XI 280
spicata XVI 94
spirata XVI 94
striata XI 279
substriata XVI 94
"x" XII 145, XVI 82, XVII 117
lageniformae, Voorthuyseniella XII 145
lageniformis, Voorthuyseniella XII 145, XII 158
laguncula, Cyrtopera XX 26
Laguncularia racemosa XII 107
lainei, Melongena XVI 149
lajollaensis, Lyrischapa XV 122, XV 124, XV 125
lajollaensis, Pejona XV 124
lajollaensis, Volutocristata XV 124
lajollaensis, Volutospira (Pejona) XV 124
lamarckiana, Quinqueloculina XI 274, XI 284
Lamarckina XI 300
atlantica XI 300
claibornensis XI 8
lamellatus, Mytilopsis XVIII 165
lamellosa, Bursa XI 126
lamellosa, Daphnellopsis XI 97
Lampas XIV 88
lamposa, Spiroloculina XVIII 16
lamposus, **NEAGUITES** *XVIII 12, XVIII 16*
Lamprocyclas
heteroporos XX 28
martalis XX 30
Lamprocyrtis XX 28
hanni XX 28
heteroporos XX 28
lamyi tampae, Glycymeris XII 143
lanceolata, Bolivina XI 282, XI 292
Lanistaina XIX 165
Lanistes XIX 165
lanosum, Lanternosphaeridium XII 189
lanosum cf., Lanternosphaeridium XII 189, XII 206
Lanternithus XI 240
duocavus sp. cf. XVII 31
minutus XI 10, XI 240
Lanternosphaeridium XII 188
bipolare XII 188, XII 206
lanosum XII 189
lanosum cf. XII 189, XII 206
lapicida, Venus XII 47, XII 163
lapidaris, Ophiobolus XII 224, XII 228
lapidaris, Scuticabolus XII 228
lapidiscola, Touroconcha XIX 139
Larcospira XX 16
minor XX 16
quadrangula XX 16, XX 18
Larnacantha polyacantha XX 18
LASAEIDAE *XVII 103*
Lataxiena XIV 131
bombayanus XIX 86
lateralis, Mulinia XVII 103, XVIII 104, XIX 61, XIX 106
lateralis, Modiolaria XIX 165

lateralis, Musculus XIX 165
lateralis, Poroeponides XVI 94
lateralis **PRAELATERALIS**, *Musculus (Ryenella) XIX 162*, **XIX 164**
Lathyrus XIII 196
latiformis jamaicensis, Saracenaria XVI 94
Latirofusus XIII 196
exilis XIII 197
Latirus XII 134, XIII 196
leaensis XIII 195
obtusus XIII 195
singleyi XIII 195
Latirus (Dolicholatirus) apenninicus XIII 196
Latouchella accordionata XVI 72
latum, Cytheropteron XII 65
latus, Rhoipites XVII 29
lauta, Denticula XX 46
lavrani, Cardium (Cerastoderma) XVI 38
leaensis, Latirus XIII 195
Ledina smirna XVII 33
legumen, Dentalina XIV 83
lehneri, Globorotalia XI 11
lenticularis, Discoaster XI 58, XI 64, XIX 9
Lenticulina XIV 84, XIX 182
bowdenensis XVI 92
calcar XVI 92
cibaoensis XIV 94
cristobalensis XIV 94
falcifer XVI 92
guttata XIV 94
hanseni XIV 94
inusitatus XIV 85
iotus XVI 94
macomberi XVII 117
striata XIV 94
subalata XIV 86
yaguatensis XIV 94
Lenticulina (Robulus) cristi XIV 94
Lenticulites XIV 88
Leodia XVIII 137
sexiesperforata XVIII 141
leonensis, Cytherelloidea XIV 156, XIX 139
leonensis sp. aff., Cytherelloidea XIV 154, XIV 156
leonensis, Cytheropteron XII 68
lepida, Koczyia XI 34
Lepidocyclina XII 141, XV 106, XVII 135
chaperi XII 141
fragilis XII 142
lepidotus, Chicoreus XII 17
lepidum, Lepton XVII 103
Leptocardia XVI 7
Leptocythere XII 74
paracastanea XII 74, XII 82, XIV 148
LEPTOCYTHERIDAE *XII 74, XIX 155*
Lepton lepidum XVII 103
LEPTONIDAE *XVII 103*
leptopora, Coccosphaera XV 14
leptopora, Cyclococcolithina XI 24, XI 119, XV 14, XV 26, XIX 26
leptoporas, Coccosphaera XI 195
leptoporus, Coccolithus XV 14
leptoporus, Cyclococcolithus XI 196, XV 14, XVI 87
Leptoreodon marshi cf. XV 85
lesquereuxianus, Tetracolporopollenites XVII 29
lessoni var., Amphistegina XV 5
lessonii, Amphistegina XI 88, XI 294, XVI 94
leucoderma, Murex XI 127
leucophaeata, Mytilopsis XVII 104
leucopheatus, Mytilus XVIII 163
leucostephes, Hertleinella XII 105
leucostomum, Cardium XIII 161
leucostomum, Laevicardium (Trachycardium, Acrosterigma) XVI 36
levis, Loxoconcha XIX 156
libertiensis, Muricidea XII 109
libyca, Dimya XV 50
Liliacidites
tritus XVII 28
vittatus XVII 29
lilium hunteria, Fasciolaria XVII 101
lima, Dimya XV 50
LIMATA, *Lyria (Lyria)* **XIV 111**, *XIV 116*
limatula, Yoldia XIX 108
limbata denticulata, Spirillina XI 288
limbata, Muelleriella XX 52, XX 56
limbata, Rotalia XV 11
limbatus, Discoaster XIX 9
limitata, Pseudoplicapollis XVII 39
Limnocythere XIV 156, XIX 152
sanctipatricii XIV 156
sappaensis XIX 154
sp. XIV 154, XIV 156, XIX 150, XIX 152, XIX 154
staplini XIX 154
LIMNOCYTHERIDAE *XIV 156, XIX 152*
limpida, Deflandrea XII 193
lineata, Articulina XI 277
lineata, Siphocampe XX 34
lineatus, Discolithus XI 206
lineolata, Mitra XIX 96
Linga
amiantus XVII 103
pensylvanica XIX 61
lingi, Dictyocha XX 88
linguabison, Vitularia XIII 192
linguabovis, Vitularia XIII 192
linguatigris, Cardium (Trachycardium) XIII 164
Linhuris XIV 88
linneiana, Triloculina XI 276
linneiana comis, Triloculina XI 276
Linthurus XIV 88
Linum sulcatum XIII 26
Liochlamys bulbosa XII 116
liodes, Oliva XVI 114
liodes, Oliva (Oliva) XVI 114
liodes, Oliva (Omogymna) XVI 114, XVI 116
liodes waltoniana, Oliva XVI 107
LIPPSINA XVIII 160
lisbonensis, Ostrea XI 4, XI 181
lisbonensis, Pentaster XI 192, XI 224
listeri, Tellina XIX 61
Lithamphora furcaspiculata XX 34
LITHASTERINOIDEAE *XII 166*
Lithastrinus XII 166

Lithatractus XX 13
timmsi XX 13, XX 14
LITHELIIDAE *XX 16*
Lithelius XX 16
minor XX 16, XX 18
nautiloides XX 16, XX 18
LITHISTIDA *XVI 129*
Lithobotrys denticulata XX 18
Lithocarpium XX 18
polyacantha XX 18
Lithodesmium XX 52
asketogonium XX 52, XX 56
cornigerum XX 52, XX 56
minusculum XX 52, XX 56
Lithodoma XIX 169
Lithodomus XIX 169
antillarum XIX 169
biexcavatus XIX 170
bisulcatus XIX 170
caudigerus XIX 170
straminius XIX 169
Lithopera denticulata XX 18
Lithophaga XIX 169
antillarum XIX 166, XIX 169
appendiculata XIX 170
cookei XIX 171
dactylus XIX 169
mytuloides XIX 169
nigra XIX 170
oryzoides XIX 170
plumula XIX 170
straminea XIX 169
Lithophaga (Diberus) bisulcata XIX 166, XIX 170
Lithophaga (Lithophaga) antillarum XIX 169
Lithophaga (Myoforceps) aristata XIX 170
LITHOPHAGINAE *XIX 169*
Lithophagus XIX 169
caribaeus XIX 169
lithophagus, Mytilus XIX 169
Lithostromation XI 55
operosum XI 202, XI 236
perdurum XI 202, XI 236, XV 14, XV 26
reginum XI 204, XI 236
reticulum XI 204
robustum XI 204
simplex XI 204, XI 236
triangularis XI 204
LITHOSTROMATIONACEAE *XI 55, XI 202*
Lithothamnium XI 96, XVII 51
Lithromitra bramlettei XX 30
Litiopa melanostoma XVII 100
littorala, Aurila XII 69
Littorina irrorata XVII 100
LITTORINIDAE *XVII 100*
LITUOLACEA *XI 271*
LITUOLIDAE *XI 271*
LITUOLINAE *XI 271*
liveoakensis, Jaspidella XVI 119
liveoakensis, Olivella XVI 106
livida, Odostomia XVII 102
locketti, Anomocytheridea XIV 140
lodoensis, Discoaster XI 56, XI 64, XI 72
longicollis, Marginulina XIV 94
longiforma, Vaginulina XVII 35
longipollinius, Tetracolporopollenites XVII 29
longisetosa sp. aff., Bairdia XIX 138
longispina, Cytheridea XIX 152
longispina, Dictyocha XX 86
longispina, Distephanus XX 90
longispinus, Distephanus XX 90, XX 92
longissima, Thalassiothrix XX 64, XX 66
lonsdalei, Endopachys XI 173
Lopatinia XVIII 71
Lopha XIII 190
FRONDICULA XIII 190
frons XIII 190
Lophocardium XVI 7
Lophodolithus XI 29
mochlophorus XI 29, XI 218
rotundus XI 26, XI 29
lophota, Helicopontosphaera XI 36, XI 40, XI 212, XI 216
lophota, Helicosphaera XI 214
loset, Ocinebrina XIX 81
lososnensis, Neococcolithes XI 70, XIX 32
LOUISIANENSIS, *Munseyella* **XII 80**
LOUISIANENSIS, *Protocytheretta* **XII 88**
lowmani, Bolivina XI 282
Loxocardium XVI 7, XVI 18
formosum XVI 14, XVI 16
Loxoconcha XII 72, XIV 145, XIX 156
anderseni XIV 146
australis XII 73
avellana XII 74
fischeri XIV 148
helenae sp. aff. XIX 139
levis XIX 156
matagordensis XII 72, XIV 146, XIX 139
matagordensis cf. XII 72, XII 82, XIV 146, XIV 152
metagordensis XIV 146
MORALESI XII 72, *XII 82*
perdcora cf. XVII 34
postdorsoalatum XIV 146
purisubrhomboidea XII 72
purisubrhomboidea aff. XII 72, XII 82
sarasotana XII 73
sarasotana sp. cf. XIV 145, XIV 152
sp. XIX 139
wilberti XII 73, XIX 139
LOXOCONCHIDAE *XII 72, XIV 145, XIX 156*
Loxocorniculum XIV 146
fischeri XIV 146, XIV 152
postdorsoalatum XIV 146, XIV 152
tricornatum XIX 139
LOXOSTOMIDAE *XI 296*
Loxostomum XI 296
gelbi XVI 94
porrectum XI 296
sp. XI 296
Lucianorhabdus dispar XI 244
lucida, Entosolenia XI 279
lucida, Fissurina XI 279
lucida cf., Fissurina XI 279, XI 290
lucifuga, Nubecularia XI 273
lucifuga cf., Nubecularia XI 273

Lucina XI 181, XVI 43
childrenae XVII 135
contorta XVII 135
gigantea XVII 136
megameris XVII 135
pectinata XIX 61
radians XIX 61
Lucina (Pseudomiltha) sp. XVII 135
LUCINIDAE *XVII 103, XVII 135*
lucunter, Echinometra XIII 114
Ludbrookia XVI 42
ludoviciana, Cardamine XIII 61
lumina, Cepekiella XI 208, XI 236
lumina cf., Cepekiella XVII 31
luminus, Cyclococcolithus XI 236
lunata, Mitrella XVII 101, XIX 108
lunata, Virgulinella XIII 140
lunulata, Crassinella XVII 103
Lunulicardium XVI 7
retusa XVI 7
lusitanicus, Cyclococcolithus XI 24, XI 195
lusitanicus, Coccolithus XI 24, XI 195
lutheri, Probeloceras XVII 49
Luvula XII 60, XII 76
gigarton XII 77, XIX 139
GIGARTONOIDES XII 76, *XII 82*
palmerae XII 77
sp. XII 77, XII 82
luzonica, Brissopsis XVIII 135
lychnia, Poirieria (Panamurex) XII 103
LYCHNISCOSA *XVI 142*
Lychnocanium grande XX 24
Lychnocanoma XX 24
grande XX 24
sp. XX 24
Lycopodium
corallinum XIII 61
hamulatum XVII 29
lyelli, Periarchus XI 181, XII 141
lyelli floridanus, Periarchus XII 141
Lymingtonia rhetor cf. XVII 28
LYMNOCARDIIDAE *XVI 43*
LYMNOCARDIINAE *XVI 7*
Lymnocardium XVI 4
lyra, Navicula XX 52
lyratum, Cardium XVI 7
lyratum, Nemocardium (Lyrocardium) XVI 30, XVI 34
Lyria XIV 107
beauii XIV 111
carolinensis XIV 113
citrusensis XIV 122
costata XIV 109
dalli XIV 124
decorata XIV 109
heilprini XIV 110
heilprini tampaensis XIV 114
mansfieldi XIV 122
mississippiensis XIV 109
mississippiensis sp. cf. XIV 110, XIV 116
musicina XIV 124
musicina dalli XIV 124
nestor XIV 109
pulchella XIV 112
pulchella soror XIV 112
pycnopleura XIV 126
pycnopleura eocenia XIV 120
silicata XIV 110
sp. XV 120
tampaensis XIV 114
vaughani XIV 128
vegai XIV 113
wilcoxiana XIV 108
willcoxiana XIV 108
zebra XIV 114
Lyria (Enaeta)
cylleniformis XIV 118
economia XIV 115
guildingi XIV 120
isabellae XIV 115, XIV 120
OLSSONI XIV 116, *XIV 120*
perturbatrix XIV 118, XIV 120
reevei XIV 120
Lyria (Harpeola)
carolinensis XIV 113, XIV 118
heilprini XIV 114, XIV 118
Lyria (Lyria)
INCOMPERTA XIV 112, *XIV 118*
INEDITA XIV 108, *XIV 122*
LIMATA XIV 111, *XIV 116*
mississippiensis XIV 109, XIV 116
nestor XIV 109, XIV 116
pulchella XIV 112, XIV 118
silicata XIV 110, XIV 122
wilcoxiana XIV 108, XIV 120
Lyria (Sannilyria) pulchella XIV 112
lyrifera, Brissopsis XVIII 135
LYRIINAE *XIV 107*
Lyrischapa XV 118
chiapasensis XV 120, XV 122
harrisi XV 118, XV 120
lajollaensis XV 122, XV 124, XV 125
Lyrocardium XVI 7
lyroidea, Volutalithes XIV 108
LYSSACINA *XVI 136*
LYSSACINOSA *XVI 136*
Lytechinus varigatus XIII 122

M

maastrichta, Membranosphaera XVII 37
macellus, Ellipsolithus XIX 8
macgintyi, Murexiella XI 148
Machaerina XII 76
tenuissima XII 76
tenuissima cf. XII 76, XII 82
macintyrei, Cyclococcolithina XV 14, XV 26
macintyrei, Cyclococcolithus XV 14
maclurii, Endopachys XI 174
maclurii, Turbinolia XI 173
macneili, Poirieria (Panamurex) XII 102
Macoma
constricta XVII 103

tenta XVII 103, XIX 108
macomberi, Lenticulina XVII 117
Macrauchenia XVII 5
Macrocallista
maculata XIX 61
nimbosa XVII 104, XIX 61
MACROCYPRIDIDAE *XII 58, XIV 139*
Macrocyprina XII 58, XIV 139
propinqua XII 59, XIX 139
SKINNERI XII 58, *XII 66*
sp. XIV 139, XIV 146
Macrocypris
decora XII 59
schmitti XII 59
Macrodites XIV 88
macrolaccus munseyi, Haplocytheridea XVII 34
macroporus, Cristallolithus XV 14, XV 26
macroporus, Discolithina XV 14
macroporus, Discolithus XI 240, XV 14
Macroscenella montrealensis cf. XVI 72
MACSOTAYI, *Callistocythere XIX 150,* **XIX 155**
Mactra fragilis XVII 103
MACTRACEA *XVI 43*
MACTRIDAE *XVI 43, XVII 103*
maculata, Macrocallista XIX 61
maculatum, Cardium XIII 164
maculatus, Cestodiscus XX 43, XX 48
maculosum, Cardium XIII 164
Maculotriton XI 97
Madracis mirabilis XI 87
magdalensis, Turbinella XVIII 50
magdalensis, Xancus XVIII 52
magellanica, Perna XIX 160
magellanicus, Murex XII 104
mageri, Cardium XVI 41
magharense, Nemocardium XVI 6
magnifica, Deflandrea XII 193, XII 210, XVII 37
magniventra, Pellucistoma XII 78, XII 86, XIX 139
magnum, Cardium XIII 161, XVI 6
magnum, Trachycardium XIII 161
major, Equus, XV 59
major, Pemma XI 48, XI 51
major, Stenocypris XIX 148
Malluvium XVII 51
Malzella conradi XIX 139
mamillaris, Hercotheca XX 52, XX 56
MAMMALIA *XI 110*
mammillosa, Palythoa XIII 130
mangle, Rhizophora XII 107
Manicina aerolata XIII 122
mansfieldi, Falsilyria XIV 122, XIV 124
mansfieldi, Lyria XIV 122
mantelli, Eurete XVI 138
Manticoceras
rhynchostoma XVII 49
simulator XVII 49
MANZANELLIDAE *XVIII 161*
maoria, Dimya XV 50
Maoricardium XVI 7
maraisi, Pygmaepterys XVI 52
marchina cf., Candona XII 66, XII 93
Margariona XV 38
margaritaceus, Aulacodiscus XX 42, XX 48
margaritae, Globorotalia XV 11, XIX 130
margaritae, Globorotalia (Globorotalia) XV 11, XV 20, XVI 145
margaritae, Globorotalia (Obandyella) XVIII 26
margaritaceium, Periploma XVII 104
margaritifera, Cythere XII 84
margaritifera, Echinocythereis XII 84, XII 90, XIX 139
margatensis, Calcocyclas XX 28
marginalis, Orbulites XI 279
marginalis, Orbitolites XI 279
marginalis, Sorites XI 278
marginata, Bulimina XI 282, XI 292, XVI 94
marginata, Fissurina XVI 94
marginata lucida, Entosolenia XI 279
marginata lucida, Fissurina XI 279
marginatus, Coscinodiscus XX 44, XX 52
Marginella XII 9
apicina XVII 101
bella XI 308
bella inepta XI 308
inepta XI 308
Marginulina XIV 85
glabra cf. XVII 35
hirsuta var. XV 6
longicollis XIV 94
pecketi XV 6
pecketi spinosa XV 6
perprocera XVI 94
striatula XVI 94
superba XIV 94
toulmini XIV 94
marginulinoides, Nodosaria XIX 191
Marginulinopsis XIV 88
Margocolporites cribellatus XVII 39
maritalis, Lamprocyclas XX 30
Markalius XI 196, XIX 28
astroporus XI 196, XIX 24, XIX 28
inversus XI 196, XI 228, XVII 31, XIX 28
reinhardtii XIX 28, XIX 36
marmoreus, Conus XII 3
marshi cf., Leptoreodon XV 85
martensii, Oliva (Omogymna) XVI 110, XVI 116
Marthasterites XI 69
bramlettei XIX 9
contortus XIX 9
furcatus XI 66, XI 69, XI 72
hohnensis XI 69
reginus XI 204
tribrachiatus XI 11, XIX 8
martinensis, Torcula XII 142
martinensis, Turritella XII 138, XII 139
martinensis henkeri, Torcula XII 142
martini, Conarachnium XX 22
martinii, Ericsonia XIX 38
martinii, Prinsius XIX 36
martinii cf., Prinsius XIX 22, XIX 28, XIX 38
Martinottiella XIX 182
marylandicus, Conus XII 7
Massilina XI 275, XVIII 10
decorata XVIII 5
jacksonensis XVIII 12

jacksonensis punctatocostata XVIII 12
secans XI 275
Mastodon americanus XV 59
matagordanum, Nonion XI 298
matagordensis, Loxoconcha XII 72, XIV 146, XIX 139
matagordensis cf., Loxoconcha XII 72, XII 82, XIV 146, XIV 152
MATERCULA, *Dermomurex (Dermomurex)* **XI 133,** *XI 138*
Matthevia XVI 65
variabilis XVI 67, XVI 68, XVI 69
matuyamai, Eucyrtidium XX 28
maura, Oliva XVI 107
mauritianum, Cardium XVI 38
mauryae, Poirieria (Panamurex) XII 102, XII 112
maxima, Voorthuyseniella XII 158
mayori, Articulina XI 277, XVI 94
mayori, Rotaliammina XI 272, XI 280
mcgregorii, Pistillipollenites XVII 30
mckennai, Truncorotataloides (Acarinina) XII 237
Meandrina meandrites XIII 116
meandrites, Meandrina XIII 116
MEANDROPSININAE *XI 278*
media, Trigoniocardia (Americardia) XIII 166, XIII 184, XVI 24
mediatena, Cytheridea XIX 150
medicago, Murexsul XIX 87
mediosus, Discoaster XIX 9
mediterranea, Neomonoceratina XII 93, XII 97
mediterranensis, Planorbulina XI 294, XVI 94
medium, Cardium XIII 184, XVI 5
medusa, Dictyocha XX 88, XX 90
meesmanni, Strioterebrum XVIII 65
Megacythere XIV 150
johnsoni cf. XII 93, XII 97
EDWARDSI XIV 150, *XIV 152*
repexa XIX 139
robusta XIV 150
stephensoni cf. XII 93, XII 97
striata XIV 150
megadolium, Tetracolporopollenites XVII 29
megaexactus, Cyrillaceaepollenites XVII 29
Megaloraphium XVI 125
megameris, Lucina XVII 135
megameris, Miltha (Eomiltha) XVII 135, XVII 137
megameris, Phacoides XVII 135
megameris, Phacoides (Pseudomiltha) XVII 135
megameris, Pseudomiltha XVII 135
Megatherium XVII 5
Melampus bidentatus XVII 102
melanostoma, Litiopa XVII 100
mellisum, Cardium XVI 7
mellisum, Incacardium XVI 16
Mellita XVIII 137
quinquiesperforata XIX 53
sexiesperforata XIX 53
Mellopegma XVI 75
georginensis XVI 75
Melonis
affinis XVIII 32
barleeanus XVI 92
Melosira XX 52
biseriata XX 52, XX 56
clavigera XX 52, XX 56
coronata XX 52, XX 56
siberica XX 52, XX 56
sulcata XX 52
Melothria pendula XIII 61
melo, Oolina XVI 94
Melongena XVI 149
armigerus XVI 150
corona XVI 149, XVII 101
fasciata XVI 149
lainei XVI 149
subcoronata XVI 152
melongena, Murex XVI 149
MELONGENIDAE *XVI 149, XVII 101*
membranaceus, Spiniferites XII 190
Membranipora spp. XIX 108
Membranosphaera XII 177
maastrichta XVII 37
menardii, Globorotalia XI 302, XIV 31, XIV 64, XIV 74, XVI 84, XVI 94
menardii, Rotalia XIV 66, XV 11
menardii miocenica, Globorotalia XVIII 34
menardii multicamerata, Globorotalia XV 11
menardii tumida, Pulvinulina XIV 68
meningoi, Triloculina XI 275
Meoma ventricosa XVIII 141
mera, Planulina XVI 94
Mercenaria campechiensis XVII 104
MERGUS, *Chicoreus (Chicoreus)* **XI 91,** *XI 92*
merletta, Grammatophora XX 50, XX 54
Mesocena XX 94
borderlandensis XX 94
circulus XX 94, XX 100
circulus sp. cf. XX 94, XX 100
diodon XX 94, XX 100
elliptica XX 94, XX 100
hexagona XX 94, XX 100
hexalitha XX 94
nodosa XX 94
polymorpha XX 94
quadrangula XX 94, XX 98
triangula XX 94, XX 100
mesocostalis, Puriana XII 72
MESODESMATIDAE *XVII 103*
mesophthalma, Dictyocha XX 90
mesophthalmus, Distephanus XX 90, XX 94
messorius, Murex XI 153, XV 112
metagordensis, Loxoconcha XIV 146
Metaxytherium XIV 162
metula, Sphenaster XV 13
mexicana, Bolivina XVI 168
mexicana, Bolivina (Brizalina) XVI 168
mexicana, Cassidulinoides XVI 94
mexicana, Chilostomella XV 6
mexicana, Cristellaria XIV 94
mexicana, Cyprideis XIV 140, XIV 146
mexicana sp. cf., Cyprideis XIX 138
mexicana, Fursenkoina XI 296, XI 298
mexicana, Globigerapsis XI 11
mexicana, Valvulinaria XVI 94
mexicana, Virgulina XI 296

mexicanum, Elphidium XI 292
mexicanus, Fusus XII 133, XII 134
mexicanus, Urosalpinx XII 133
Mexicardia XVI 7
michelini, Encope XVIII 141
Micrantholithus XI 49, XI 189
altus XI 189, XI 220
angulosus XI 189, XI 191, XI 216
basquensis XI 50, XI 190, XI 191
basquensis crassus XI 51, XI 191
bulbosus XI 51
concinnus XI 188
floridus XI 191
flos XI 46, XI 49, XI 188, XI 189
ornatus XI 46, XI 49, XI 189, XI 212
parasiensis major XI 51
parisiensis XI 191
parisiensis major XI 191
procerus XI 46, XI 49, XI 189, XI 216
serratus XI 192
stradneri XI 192
vesper XI 190
Microcardium XVI 7
williami XVI 40
Microcytherura choctawhateensis XIX 139
MICRODINIACEAE *XII 224*
Microdinium XII 220
dentatum XII 220
echinatum XII 220
setosum XII 220, XII 222
Microfasciolites XVIII 20
microfoveolatus, Momipites XVII 29
Microfragum XVI 7
microgranulata, Deflandrea XII 195
microhenricii, Quercoidites XVII 28
microporus, Circodiscus XX 13, XX 14
microporus, Porodiscus XX 13
microporus, Trematodiscus XX 13
Micula XIX 44
decussata XIX 44
decussata decussata XIX 32, XIX 44
staurophora XVII 32, XIX 44
midwayensis, Anomalina XVII 35
midwayensis, Clavulinoides XVII 35
midwayensis, Eucythere XVII 34
midwayensis, Hermanites XVII 34
midwayensis, Robulus XVII 35
Milfordia incerta XVII 39
Miliammina XI 271
fusca XI 271, XI 280
miliaris, Murex XIII 194
miliaris, Nucinella XVIII 161
miliaris, Nucula XVIII 161
miliaris, Vitularia XIII 192
Miliola XVIII 5
byramensis XVIII 8
disticha XVIII 6
jacksonensis XVIII 3, XVIII 8
ROLANDI XVIII 8
saxorum XVIII 5, XVIII 6, XVIII 8
sp. XVIII 8
trigonula XI 276
MILIOLACEA *XI 272, XVIII 3*
MILIOLIDAE *XI 273, XVIII 3*
MILIOLINA *XI 272, XVIII 3*
Miliolina
cuvieriana XI 274
funafutiensis XI 274
subrotunda XI 276
MILIOLINAE *XI 277, XVIII 4*
Miliolinella XI 276
circularis XI 276, XI 286
fichteliana XI 276, XI 286
labiosa XI 276, XI 288, XVI 94
suborbicularis XI 277
MILIOLINELLINAE *XI 276*
Millepora
complanata XIII 130
sp. XIII 118
milletti, Buliminella XI 280, XI 292
Miltha XVII 135
Miltha (Eomiltha) megameris XVII 135, XVII 137
MILTHINAE *XVII 135*
mimula, Dimya XV 50
minax, Cornulina XVI 150
minax compressa, Cornulina XVI 150
minimus, Modiolus (Gregariella) XIX 169
miniscula, Crenella XIX 162, XIX 164
minor, Argilloecia XII 60
minor, Deflandrea XII 193, XII 210
minor, Ensis XVII 103
minor, Larcospira XX 16
minor, Lithelius XX 16, XX 18
minor, Nannippus XI 110, XI 111
minusculum, Lithodesmium XX 52, XX 56
minuta, Dictyocha XX 92
minuta, Endopachys XI 173
minuta, Stetsonia XI 286, XI 294
minutus, Basslerites XII 90, XIV 154, XIX 138, XIX 155
minutus, Distephanus XX 92, XX 94
minutus, Lanternithus XI 10, XI 240
minutus, Neococcolithes XI 238
minutus, Zygolithus XI 70, XI 238
miocenica, Basslerites XIV 155
MIOCENICA, *Basterotia (Basterotella)* **XVI 161**, *XVI 163*
miocenica, Globorotalia (Globorotalia) XVI 146
miocenica, Globorotalia (Menardiella) XVIII 24, XVIII 34
miocenica, Nitzschia XX 54, XX 58
miocenica, Pavonina XVI 94
miocenica, Pterygocythereis XII 85, XII 90
miocenica, Reussella XVI 94
miocenica, Thalassiosira XX 62, XX 64
miocenica, Virgulina XIII 140
miocenicus, Basslerites XII 90
MIOCICA, *Papyridea XIII 162,* **XIII 168**, *XIII 178*
mira, Discorbis XI 286, XI 292
mirabilis, Cyclococcolithus XV 14
mirabilis, Madracis XI 87
mirabilis, Strigilla XVII 103, XIX 61
mirabilis, Umbilicosphaera XI 119, XV 14, XV 28, XVI 87, XVIII 26
miralestense, Artostrobium XX 32

miralestensis, Botryostrobus XX 32
miralestensis sp. cf., Botryostrobus XX 30, XX 32
mirus, Discoaster XI 58, XI 62, XI 64
mississippiensis, Buliminella XVII 47
mississippiensis, Chamelea XVIII 75
mississippiensis, Fulgoraria XIV 107
mississippiensis, Lyria XIV 109
mississippiensis, Lyria (Lyria) XIV 109, XIV 116
mississippiensis, Notiotitanops XV 85
mississippiensis, Oliva XVI 106
mississippiensis, Otocheilus XIV 107
mississippiensis, **PICOUINA** *XVIII 10, XVIII 14*
mississippiensis, Proscutella XI 181
mississippiensis, Textularia XV 6
mississippiensis, Triloculina XVIII 14
mississippiensis sp. cf., Lyria XIV 110, XIV 116
Mitra XI 96
heilprini XIX 96
lineolata XIX 96
mitra, Globicuniculus XVIII 34
mitra, Globigerinoides XVIII 24, XVIII 34
Mitra (Strigatella) perturbatrix XIV 118
Mitrella lunata XVII 101, XIX 108
Mitreola americana XIV 115
MITRIDAE *XII 33*
mochlophorus, Lophodolithus XI 29, XI 218
Modiola XIX 171
appendiculata XIX 170
cinnamomea XIX 172
corrugata XIX 169
ducatellii XIX 171
gigas XIX 171
inflata XIX 171
sulcata XIX 161, XIX 166
trapezina XIX 165
Modiolarca XIX 165
Modiolaria XIX 165
lateralis XIX 165
sp. XIX 165
MODIOLINAE *XIX 171*
Modiolus XIX 171
barbatellus XIX 168
cinnamomeus XIX 172
dalli XIX 168
ducatelii XIX 166, XIX 171
inflatus XIX 171
opifex XIX 168
silicatus XIX 171
sulcatus XIX 168
tampaensis XIX 171
tulipus XIX 171
Modiolus (Gregariella) minimus XIX 169
modiolus, Arca XIX 161
Modiolus (Brachydontes)
grammatus XIX 162
grammatus curtulus XIX 161
Modiolus (Botula) cinnamomeus XIX 172
Modiolus (Brachidontes) curtulus XIX 161
modiolus, Mytilus XIX 171
Moira atropos XIX 53
molis, Conus XII 21
MOLLUSCA *XI 85, XI 96, XI 99, XI 101, XI 103, XI 105, XI 132, XI 163, XI 176, XI 308, XII 1, XII 31, XII 33, XII 44, XII 45, XII 47, XII 105, XII 133, XII 161, XII 163, XII 235, XIV 105, XV 33, XV 118, XVI 61, XVI 107, XVII 51, XVII 57, XVIII 37, XVIII 123, XVIII 161, XVIII 163, XVIII 165, XIX 61, XIX 63, XIX 159*
MOLLYNI, *Trachycardium* **XVII 55,** *XVII 56*
molokaia, Dimya XV 50
Momipites
annulatus XVII 29
coryloides XVII 29
dilatus XVII 38
flexus XVII 38
fragilis XVII 39
microfoveolatus XVII 29
sp. A XVII 36
strictus XVII 39
tenuipolus XVII 39
Monalysidium XI 278
politum XI 278
monicae, Actinoptychus XX 41, XX 46
monicae, Coscinodiscus XX 44, XX 52
monilifera, Rousea XVII 29
moniliformis, Neritopsis XI 104
MONMOUTHENSIS, CYCLAPOPHYSIS XII 183, *XII 198, XII 200*
MONOPLACOPHORA *XVI 56, XVI 61*
monroei, Postligata XVIII 68
Montastrea
annularis XIII 124
cavernosa XIII 116
montereyanus, Arachnoidiscus XX 42, XX 46
montezuma, Protocytheretta XII 88
montezuma **LOUISIANENSIS,** *Protocytheretta* **XII 88,** *XII 90*
Montfortella XIV 103, XIX 181
bramlettei XIV 103, XIX 183
montrealensis cf., Macroscenella XVI 72
moodybranchensis, Operculinoides XII 141
mooreana, Solariorbis XVII 100
MORALESI, *Loxoconcha* **XII 72,** *XII 82*
morgani, Buliminella XVII 46
MORGANI, *Cytheropteron* **XII 65,** *XII 74, XIX 139*
moriformis, Sphenolithus XI 48, XI 54, XI 232, XI 244
moriformis, Nanoturbella XI 54, XI 232
morio, Murex XVI 149
morionum, Calyptrolithus XI 238
morionum, Rhabdosphaera XI 230
morkhoveni, Krithe XII 61
moronensis, Actinocyclus XX 41, XX 44
Morula XIX 64
necocheana XIX 84
papillosa XIX 64
rosea XIX 70
rutila XIX 77
Morulina XIII 194
morum, Drupa XIX 64
mosaicum, ?Ctenidodinium XVIII 152
mosquitensis, Risomurex XIX 66, XIX 70
mucrontata, Articulina XI 277
mucronata, Vertebralina XI 277
muelleri, Proconodontus XVI 76

Muelleriella XX 52
limbata XX 52, XX 56
muiri, Coccolithus XI 25
muiri, Ericsonia XI 25, XI 28, XI 32, XI 194
Mulinia XVIII 163
densata XVI 43
lateralis XVII 103, XVIII 104, XIX 61, XIX 106
multibrevis, Spiniferites XII 190
multicamerata, Globorotalia XIV 9
multicamerata, Globorotalia (Globorotalia) XVI 146
multicamerata cf., Globorotalia (Globorotalia) XV 11, XV 20
multicostata, Acanthocardia (Europicardium) XVI 18
multicostata, Glycymeris XVIII 73
multicostata, Daucina XIX 191
multicostata, Ellipsoglandulina XIX 191
multicostata, Orthocerina XIX 191
multicostata semicostata, Pseudoglandulina XIX 191
multicostatum, Cardium XVI 6
MULTICOSTULA, *Papyridea* XIII 158, **XIII 169**, XIII 178
multigranosus, Cantharus (Pollia) XIX 74, XIX 81
multilineata, Parvilucina XVII 103
multiliratus, Conus XII 28
multilocularis, Articulina XI 277, XI 288
multiloculata, Anaticinella XI 306
multiloculata, Globorotalia XI 306
multiloculata, Pseudoticinella XI 306
MULTIPERFORATA, *Thoracosphaera* XIX 30, XIX 32, **XIX 42**
multipora, Discolithina XI 30, XI 206, XI 208, XI 238, XV 14
multipora, Pontosphaera XI 28, XI 30, XI 32, XI 208
multiporus, Cristallolithus XV 14, XV 26
multiporus, Discolithus XI 30, XI 206, XV 14
multipunctata, Acuticythereis XIV 145
multipunctata, Proteoconcha XIV 145, XIV 150
multiradiatus, Discoaster XIX 9
multispinosum, Cordosphaeridium XVII 37
multistriatum, Epitonium XVII 100
mundum, Fragum XIII 172
munitus, Vacuopollis XVII 36
Munseyella XII 80, XVI 86
atlantica XII 80
bermudezi XII 80
bermudezi **LOUISIANENSIS XII 80**, XII 86, XIX 139
LOUISIANENSIS XII 80
sp. XII 80, XII 86
Murex
abyssicola XI 148
acuticostatus XI 130
adamsii XI 138, XII 45
alabaster XI 138, XII 45
alabastrum XI 138, XII 45
alatus XVI 46
alfredensis XVI 48
alveatus XI 122, XI 140, XIX 63
anniae XI 141
aradasii XIX 87
argo XI 90
arlus XI 128
armatus XIX 86
asteriscus XI 131
atlantis XII 102
bicolor XI 141
bisotensis XI 148
blainvillei XII 104, XIX 66, XIX 85
bombayanus XIX 86
brachys XIX 86
brazieri XIX 86
brevifrons XII 45
cancellariiformis XI 130
cancellarioides XI 130
carduus XII 118
cataphractus XIX 86
cotteavi XI 49
crassiliratus XI 129
cristatus XIX 85
cuspidatus XIX 86
distinctus XI 127
erosus XI 122
funafutiensis XVI 46
fusiformis XIX 81
gapus XI 153
gatunensis XI 152
globosus XVI 97
hexagonus XII 104
inermis XI 148
infans XIX 86
intermedius XI 122, XIX 65
iostoma XIX 86
iostomus XIX 86
jani XI 146
leucoderma XI 127
magellanicus XII 104
medicago XIX 87
melongena XVI 149
messorius XI 153, XV 112
miliaris XIII 194
morio XVI 149
nitens XIX 87
noduliferus XIX 87
obeliscus XI 140
olssoni XI 137
ostrearum XII 105, XII 133
oxytata XIX 86
pachystirus XI 130
pauperculus XI 138
pauxillus XIX 86
pazi XII 102
pinnatus XVI 46
radula XIX 86
regius XIX 168
scabriculus XII 34
scabriusculus XII 34
scalaformis XI 127
scalariformis XI 127
scalarinus XI 133
scalarioides XI 127
scalaroides XI 133

sexangula XI 152
spectrum XI 90
sutilis XV 112
rudis XI 156
taurinensis XI 156
tenellus XI 133
vaughani XI 153
zelandicus XII 102
murex, Daphnellopsis XI 97
Murex (Bolinus)
cornutus XI 153
partschi XI 153
torularius XI 153
vaughani XI 153
Murex (Chicoreus)
argo XI 90
calcitrapa XI 88
imbricatus XI 90
spectrum XI 90
Murex (Murex) vaughani XI 153
Murex (Panamurex) gilletteorum XI 152
Murex (Pterynotus) abyssicola XI 148
Murex (Trophon) tenellus XI 149
Murexiella XIII 193, XVI 46
absona XI 148
calhounensis XI 156
macgintyi XI 148
shilohensis XI 148
Murexiella (Subpterynotus) textilis XII 14
Murexsul XIII 193
brazieri XIX 86
medicago XIX 87
purpurispina XIX 87
MURICACEA *XI 132, XII 105*
muricatum, Trachycardium XVII 103
muricatum, Vasum XIII 122
MURICIDAE *XI 132, XII 105, XIII 194, XIV 131, XV 105, XVI 48, XVII 124, XIX 66*
Muricidea XII 104
attenuata XII 105
caledonica XIX 86
conradi XII 109
floridana XII 105
foridana attenuata XII 105
floridana conradi XII 109
floridana libertiensis XII 109
libertiensis XII 109
ostrearum XII 105
philippiana XII 111, XII 120
striata XII 111, XIV 131
MURICINAE *XI 132, XII 105*
muricoides, Fusus XIX 70, XIX 77
muricoides, Muricopsis XIX 77
muricoides, Ocenebra (Ocinebrina) XIX 77
muricoides, Risomurex XIX 77
Muricopsis (Muricopsis) blainvillei XIX 70
MURICOPSINAE *XIII 193, XIV 132, XVI 48, XIX 66*
Muricopsis XII 104, XIII 193, XVI 47, XIX 66, XIX 85, XIX 88
angolensis XIX 80
armatus XIX 86
blainvillei XIX 86
crassicosta XIX 84
cristatus XIX 86
cuspidatus XIX 86
floridana XII 106
huberti XIX 86
jaliscoensis XIX 86
muricoides XIX 77
nicocheanus XIX 84
oliverai XIX 87
orri XIX 87
oxytata XIX 86
purpurispina XIX 87
pauxillus XIX 86
radula XIX 86
roseus XIX 70
schrammi XIX 66
tulensis XIX 86
vistaensis XIX 65
zeteki XIX 86
Muricopsis (Risomurex) XIX 66
caribbaeus XIX 70, XIX 77
crassicosta XIX 72, XIX 84
deformis XIX 66, XIX 70
fusiformis XIX 74, XIX 81
galbensis XIX 70, XIX 83
gilbertharrisi XIX 72, XIX 78
necocheanus XIX 70, XIX 84
roseus XIX 68
rubidus XIX 68
rutilus XIX 68, XIX 80
schrammi XIX 68, XIX 76
SEMINOLENSIS XIX 88, *XIX 89*
suga XIX 74, XIX 82
WITHROWI *XIX 72,* **XIX 78**
Musculus XIX 164
lateralis XIX 165
Musculus (Planimodiola) **DISINFLATUS** *XIX 162,* **XIX 168**
Musculus (Ryenella) lateralis **PRAELATERALIS** *XIX 162,* **XIX 164**
musicina, Voluta XIV 124
musicina dalli, Lyria XIV 124
musicina, Falsilyria XIV 122, XIV 124
musicina, Lyria XIV 124
Mussa angulosa XIII 116
mutabilis, Dictyocha XX 86
mutica, Cassidaria XIX 178
mutica, Olivella XVII 101
muticum, Eudolium XIX 179
muticum, Eudolium (Galeodolium) XIX 177
Mutilus sp. XIX 139
Mya perna XIX 160
MYIDAE *XVII 104*
Mylodon XV 60
harlani XV 59
Myona queenslandica XVI 76
Myoparo XIX 164
myrakeenae, Dermomurex (Takia) XI 150
Myrica XVII 29
Myripristis XV 99
creola XV 100, XV 103
myristica, Volema XVI 149
myrmia, Harpa XVII 57, XVII 58, XVIII 56

Myrtaceidites parvus XVII 29
Mysella planulata XIX 108
MYTILACEA *XIX 160*
Mytiliconcha sp. XVI 97
MYTILIDAE *XVI 41, XVII 102, XIX 160*
MYTILINAE *XIX 160*
Mytiloconcha XIX 160
Mytiloides XVIII 163
mytiloides, Gastrochaena XII 161
Mytilopsis XVIII 163
cira XVIII 164
domingensis XVIII 165
ERIMIOCENICUS XVIII 164
jamaicensis XVIII 165
lamellatus XVIII 165
leucophaeta XVII 104
Mytilus
canoasensis vidali XIX 161
citrinus XIX 161
cristagalli XIII 190
decussatus XIX 164
discors XIX 165
fuscus XIX 172
impactus XIX 165
inflatus XIX 171
leucopheatus XVIII 163
lithophagus XIX 169
modiolus XIX 171
mytuloides, Lithophaga XIX 169

N

naheolensis cf., Virgulina XVII 35
nana, Rheophax XI 271, XI 280
Nannippus XVII 72
gratus XI 112
ingenuum XI 111
minor XI 110, XI 111
phlegon XI 111
Nannodiella oxia XVII 102
NANNOFOSSILS *XI 1, XI 80, XI 115, XI 179, XII 166, XV 1, XVIII 21*
Nannotteraster staurophorus XIX 44
Nannoturbella moriformis XI 54, XI 232
NASSARIIDAE *XVII 101*
Nassarius
acutus XVII 101
trivittatus XIX 108
vibex XVII 101
NASSELLARIA *XX 18*
nasuta, Pyrgo XVI 94
NATICIDAE *XVII 101*
nativa, Thalassiosira XX 62, XX 64
NAUTILIDAE *XII 237*
Nautilina XIV 88
NAUTILOIDEA *XII 235*
nautiloides, Lithelius XX 16, XX 18
Nautilus
angulatus XI 278
pertusus XI 278
Nautilus (Lituus)
acicularis XI 278
arietinus XI 278
Nautilus (Orthoceras) comatus XIX 191
Navicula XX 52
ehrenbergii XX 52, XX 56
lyra XX 52
optima XX 52, XX 56
navis, Cativella XIX 138
NEAGUITES XVIII 14
byramensis XVIII 12, XVIII 15
imprimatus XVIII 16
INUSITATUS *XVIII 10,* **XVIII 15**
lamposus XVIII 12, XVIII 16
sp. XVIII 10
NEAGUITITESINAE XVIII 14
neapolitana, Uncimenia XVI 65
Nearomya floridana XVII 103
nebulosa, Cochlea XIII 160, XVI 8
necocheana, Morula XIX 84
necocheanus, Muricopsis (?Risomurex) XIX 70, XIX 84
neelyi cf., Cibicides XVII 35
NEMATOGLOSSA *XII 33*
nemo, Laevicardium XVI 38
Nemocardium XVI 7
cingulatum XVI 34
griphus XVI 5
magharense XVI 6
Nemocardium (Arctopratulum) XVI 20
griphus XVI 28, XVI 34
Nemocardium (Discors) XVI 20
parisiense XVI 30
Nemocardium (Divaricardium) XVI 20
discrepans XVI 34
Nemocardium (Frigidocardium) XVI 20
eos XVI 34
Nemocardium (Habecardium) XVI 20
tenuisulcatum XVI 34
Nemocardium (Keenaea) XVI 22
samarangae XVI 34
Nemocardium (Lophocardium) XVI 20
cumingii XVI 30
Nemocardium (Lyrocardium) XVI 22
lyratum XVI 30, XVI 34
Nemocardium (Microcardium) XVI 22
peramabile XVI 30
Nemocardium (Nemocardium) XVI 20
semiasperum XVI 30, XVI 34
Nemocardium (Pratulum) XVI 22
pulchellum XVI 34
thetidis XVI 30
Nemocardium (Trifaricardium) XVI 22
nomurai XVI 34
Nemocardium (Varicardium) XVI 22
patulum XVI 34
Nemodon XVIII 71
nemorideditus, Conus XII 22
Neocaudites XIV 152
nevianii XIV 154
scottae XIX 139
triplistriata XIV 154
triplistriata sp. cf. XIV 152, XIV 154

Neochiastozygus concinnus XVII 31
Neococcolithes XI 70, XIX 32
dubius XI 52, XI 66, XI 70, XI 238
lososnensis XI 70, XIX 32
minutus XI 238
protenus XI 70, XIX 32, XIX 40
neocomiensis, Venericardia XVI 41
Neoconorbina XI 286
orbicularis XI 286
terquemi XVI 94
NEOCYTHERIDEINAE *XII 61, XIV 141*
Neocytherideis XII 61
cylindrica cf. XII 61, XII 74
Neoeponides
antillarum XI 88, XVI 92
tumidulus XVI 94
neogammation, Cyclococcolithus XI 195
NEOGASTROPODA *XI 132, XII 3, XII 105, XV 118, XVI 107, XVI 149*
neogenica, Creusia XVI 97
Neogloboquadrina
acostaensis XVIII 26
dutertrei XVI 94
eggeri XVI 94
humerosa XVIII 26
Neolaganum XVIII 137
archerensis XVIII 130
dalli XVIII 130
Neomonoceratina mediterranea XII 93, XII 97
Neomophila australis XIII 61
Neomonopleura XVII 51
weidenmayeri XVII 51
Neonesidea XII 58, XIV 139
gerda XIV 139
gerda sp. cf. XIV 139, XIV 146
sp. XII 58, XII 66
Neopilina XVI 59
galatheae XVI 59
Neopleurodon XVIII 161
subdolus XVIII 161
Neoseptigerina XVIII 159
nepenthes, Globigerina XIV 9, XV 11, XV 14, XVI 146, XVIII 22, XVIII 34, XIX 127
nepenthes constricta, Sphaeroidinellopsis XV 11, XVIII 34
nereidis, Otocheilus XIV 110
Nereis XVI 58
Nereites XIX 91
Nerita XVII 132
albicilla XVII 132
caronis XVII 132
exuvia XVII 131
exuvioides XVII 132
fulgurans XVII 131
funiculata XVII 131
peloronta XVII 132
plutonis XVII 131
spp. XIII 114
tessellata XVII 131
NERITACEA *XI 103*
Nerita (Nerita) exuvioides XVII 132
Nerita (Theliostyla)
exuvia XVII 132
exuvioides XVII 132
fulgurans XVII 132
NERITIDAE *XVII 100*
Neritina
chipolana XVI 159
recliviata XVII 100
virginea XVII 100
NERITOPSIDAE *XI 103*
NERITOPSINAE *XI 103*
Neritopsis XI 103
atlantica XI 176
FINLAYI *XI 103*, **XI 104**, *XI 176*
moniliformis XI 104
radula XI 103
vokesorum XI 104, XI 168
Nesidea cushmani XIV 137
nestor, Lyria XIV 109
nestor, Lyria (Lyria) XIV 109, XIV 116
Neverita duplicatus XVII 101
nevianii, Neocaudites XIV 154
newberryensis, Spiroloculina XII 141
NEWBURNENSIS, *Balanus* **XVI 100**, *XVI 102*
newtoni, Fragum XVI 5
nicocheanus, Muricopsis XIX 84
nicocheanum, Sistrum XIX 84
nidulus, Stephanopyxis XX 64
nidulus, Thalassiosira XX 62, XX 64
nigra, Lithophaga XIX 170
nigripites, Juglans XVII 28
nilssoni, Dimyodon XV 51
nilssoni, Ostrea XV 51
nimbosa, Macrocallista XVII 104, XIX 61
nipeensis, Caudites XIX 138
Nipponotrophon XII 120, XIV 131
nitens, Ergalatax XIX 87
nitens, Murex XIX 87
nitida, Candeina XIV 26, XIV 54, XIV 60, XV 11, XVI 94, XVI 146
nitida nitida, Candeina XV 11, XV 14, XVIII 24
nitidus, Coscinodiscus XX 44, XX 52
Nitzschia XX 54
californica XX 54, XX 58
fossilis XX 54, XX 58
jouseae XX 54, XX 58
miocenica XX 54, XX 58
reinholdii XX 8, XX 54, XX 58
rolandii XX 54, XX 58
nitzschioides, Synedra XX 62
nitzschioides, Thalassionema XX 62
nivale, Trillium XIII 18
nobilis, Discoaster XIX 9
nobilis, Harpa XVIII 56
nodifer, Discoaster XI 60, XI 66, XI 199, XI 232
nodifera, Tubucellaria XII 141
Nodobaculariella XI 273
atlantica XVI 92
cassis XI 273, XVI 92
NODOBACULARIINAE *XI 273*
nodosa, Mesocena XX 94
nodosa, Paracytheridea XIV 142
Nodosaria XIV 82, XIX 182
affinis XVII 35
bambergensis XIX 191

erbessina XIX 191
fusta XVI 94
hispida XV 6
marginulinoides XIX 191
pyrula XVI 94
NODOSARIACEA *XI 279, XIV 90*
Nodosaria (Glandulina) laevigata XI 279
nodosaria, Siphocampe XX 32, XX 34
NODOSARIIDAE *XI 279, XIV 90*
NODOSARIINAE *XI 279, XIV 90*
nodosum, Cytheropteron XIV 142
nodulifer, Coscinodiscus XX 44, XX 52
noduliferus, Attiliosa XIX 87
noduliferus, Murex XIX 87
nodulosa, Attiliosa XII 134, XIV 132
nodulosa, Coralliophila XII 133
nodulosa, Peristernia XII 111, XII 133
nodulosa, Trachypollia XIX 67
nodulosum, Sistrum XIX 67
Noetia XVIII 71
ponderosa XVII 102
NOETIIDAE *XVIII 68*
NOETIINAE *XVIII 71*
nomurai, Nemocardium (Trifaricardium) XVI 34
nomurai, Trifaricardium XVI 8
Nonion XI 298
barleeanum XI 298
demens XVIII 160
depressula matagordanum XI 298
depressulum matagordanum XI 298
grateloupi XI 298
matagordanum XI 298
Nonionella XI 298
basiloba XVI 92
davanaensis cf. XX 8
opima XI 298
NONIONIDAE *XI 298*
Nonionina
barleeana XI 298
canariensis XI 271
grateloupi XI 298, XVIII 160
pelagica XIV 50
stelligera XI 298
NONIONINAE *XI 298*
Nonionoides XVIII 160
demens XVIII 160
normalis, Dyopteris XIII 61
normani, Bradleya XIX 138
norrisii, Korystocysta XVIII 154
notabile, Cardium XVI 8
notata, Diplodonta XIX 108
Notiotitanops
mississippiensis XV 85
Nubecularia XI 273
lucifuga XI 273
lucifuga cf. XI 273
NUBECULARIIDAE *XI 273*
NUBECULARIINAE *XI 273*
Nucinella XVIII 161
alleni XVIII 162
CHIPOLANA XVIII 161, *XVIII 162*
gunteri XVIII 162
miliaris XVIII 161
woodii XVIII 162
nucleatus, Anomalinoides XVI 94
nucleus, Voluta XIV 107
Nucula
miliaris XVIII 161
proxima XIX 108
sp. XVII 32
Nuculana
acuta XVII 102, XVIII 120, XIX 108
concentrica XVII 102
NUCULANIDAE XVII 102
Nuculina XVIII 161
Nuculocardia XIX 164
Nudopollis
terminalis XVII 39
thiergartii XVII 39
Nummulites
vanderstoki XII 141, XVIII 73
NUMMULITIDAE *XI 292*
nuttallii, Cardium XVI 6
nuttallii, Clinocardium (Clinocardium) XVI 28, XVI 36, XVI 38
nuttingi, Poirieria (Paziella) XII 102
Nyssa kruschii XVII 29

O

oahense, Endopachys XI 173
oamaruensis, Chiasmolithus XI 15, XI 19, XI 22, XIX 22
oamaruensis, Coccolithus XI 19
oamaruensis, Tremalithus XI 19, XI 193
obeliscus, Dermomurex XI 129
obeliscus, Murex XI 140
obesa, Anachis XVII 101
obesus, Typhis XV 112, XVII 125
obesus, Typhis (Talityphis) XVII 125, XVII 126
obliqua, Anomia XV 50
obliqua, Dimya XV 50
obliqua, Globigerinoides XIV 42, XV 12
obliquiloculata, Pullenia XIV 58
obliquiloculata, Pulleniatina XIV 28, XIV 58, XVI 84, XVI 146
obliquiloculata finalis, Pulleniatina XIV 58, XIV 66, XIV 68
obliquiloculata obquiloculata, Pulleniatina XIV 58
obliquipons, Discolithina XI 222
obliquipons, Discolithus XI 218, XI 220, XI 222
obliquipons, Transversopontis XI 34, XI 38, XI 220, XI 222, XI 240
obliquipons, Zygolithus XI 220
obliquus extremus, Globigerinoides XV 12, XV 18, XVI 145, XVIII 26
obliquus obliquus, Globigerinoides XIV 42, XV 12, XV 18, XVI 146, XVIII 26
oblonga, Basterotia XVI 157
oblonga, Triloculina XI 276
oblonga, Xanthiopyxis XX 64, XX 66
oblongata, Panopaea XVIII 167

oblongum, Cardium XIII 184, XVI 7
oblongum, Laevicardium XIII 184
oblongum, Laevicardium (Laevicardium) XVI 36, XVI 38
oblongum, Vermiculum XI 276
obovale, Cardium XVI 5
obovale, Trigoniocardia (Apiocardia) XIII 170, XIII 172
obovalis, Trigoniocardia (Apiocardia) XVI 22
obscura, Deflandrea XVII 37
obscurocostata, Basopollis XVII 30
obscurus, Coscinodiscus XX 44, XX 52
OBTURACULOIDES, *Karreriella* **XIX 185,** *XIX 186*
obtusa, Biddulphia XX 42, XX 48
obtusa, Odontella XX 43
obtusus, Latirus XIII 195
obtusus, Sphenolithus XI 55
ocalana, Rhinoclavis (Ochetoclava) XII 138
ocalanum, Amusium XII 40
ocalanum, Cerithium XII 137
ocalanum, Durhamella XVIII 130
ocalanus, Eupatagus XVIII 130
ocalanus, Schizaster XVIII 135
ocalensis, Exputens XII 143
occidentalis, Ericsonia XI 25, XI 196
occidentalis, Hauerina XI 277, XI 288
occidentalis, Helianthus XIII 26
occidentalis, Quinqueloculina XI 274
occidentalis, Trifarina XVI 94
occidentalis, Voorthuyseniella XII 145, XII 157
occidentaloides, Platanus XVII 29
oceanica, Coronifera XII 182, XII 198
oceanica, Endictya XX 48, XX 54
oceanica, Gephyrocapsa XVI 87
oceanicus, Coccolithus XI 13, XI 194, XIX 19
ocellata, Discolithina XI 34, XI 206
ocellata, Pontosphaera XI 34
ocellatus, Crepidolithus XI 34
ocellatus, Discolithus XI 34
ocellatus, Transversopontis XI 34, XI 36, XI 42
Ocenebra XI 96, XIX 63
angolensis XIX 86
Ocenebra (Risomurex)
rosea XIX 70
schrammi XIX 66
Ocenebra (Ocinebrina) muricoides XIX 77
ochotensis, Actinocyclus XX 41, XX 44
Ocinebrina XI 96, XI 130, XIX 63
fusiformis XIX 81
loset XIX 81
suga XIX 82
OCENEBRINAE *XIX 64*
oculatus, Actinocyclus XX 41, XX 44
Oculina sarasotana XVI 100
oculusiridis, Coscinodiscus XX 46, XX 52
Odontachitina costata XVII 28
Odontaspis XIV 161
Odontella obtusa XX 43
Odostomia
gibbosa XVII 102
impressa XVII 102, XVII 105, XVII 109, XVII 112
livida XVII 102
seminuda XVII 102
oestrupii, Coscinosira XX 64
oestrupii, Thalassiosira XX 30, XX 62, XX 64
ohioensis, Solidago XIII 18
Oichnus XIX 56
Olenothyris harlani XII 236
Oligopygus XVIII 128
haldermani XVIII 128, XVIII 131
phelani XVIII 128, XVIII 131
wetherbyi XVIII 128, XVIII 131
Oligosphaeridium XII 177
Oliva XII 9, XVI 107, XVII 17
angulata XVI 107
blowi cf. XVI 110, XVI 112
corticaria XVI 107
cylinderica XVI 109
gatunensis XVI 108
incrassata XVI 107
liodes XVI 114
liodes waltoniana XVI 107
maura XVI 107
mississippiensis XVI 106
oliva XVI 107
paxillus XVI 113
plicaris XVI 107
posti XVI 112
reticularis XVI 109
reticularis trochala XVI 112
sayana XVI 113, XVII 101, XIX 61
sp. XIII 112
vidau XVI 107
oliva, Oliva XVI 107
Oliva (Oliva) XVI 107
BLOWI XVI 109, *XVI 110*
liodes XVI 114
VOKESORUM *XVI 110,* **XVI 112**
waltoniana XVI 107, XVI 110
waltoniana **CALHOUNENSIS XVI 108,** *XVI 110*
Oliva (Omogymna) XVI 113
gardnerae XVI 116, XVI 119
gradata XVI 114
liodes XVI 114, XVI 116
martensii XVI 110, XVI 116
paxillus XVI 118
valens XVI 116
oliva, Voluta XVI 107
Olivella XVI 106
cofacorys XVI 119
gardnerae XVI 118
jaspidea XVI 119
liveoakensis XVI 106
mutica XVII 101
OLIVELLINAE *XVI 119*
olivencae, Darwinula XIX 147
olivencae sp. aff., Darwinula XIX 146
oliverai, Muricopsis XIX 87
oliverai, Pazinotus XIX 87
OLIVIDAE *XVI 107, XVII 101*
olivifer, Acrosterigma (Regozara) XVI 28
olivifer, Regozara XVI 8
OLIVINAE *XVI 107*

Olssonella XII 35
campbelli XII 36
PANAMICA XII 35, *XII 40*
scalatella XII 36
WILLIAMSI XII 36, *XII 40*
OLSSONI, *Lyria (Enaeta)* **XIV 116,** *XIV 120*
olssoni, Murex XI 137
Omogymna XVI 113
onestae, Integricardium (Onestia) XVI 30
onestae, Laevicardium XVI 7
Onestia XVI 7
oniscus, Corbula XV 56
Ontaria spp. XVII 48
Oolina
caudigera XVI 92
hexagona XVI 94
melo XVI 94
striata XI 279
OOLININAE *XI 279*
Opephora XX 54
schwartzii XX 54, XX 58
Operculina involvens XI 273
Operculinoides
jacksonensis XII 141
moodybranchensis XII 141
Operculodinium XII 189
centrocarpum XII 189, XII 206
operosum, Lithostromation XI 202, XI 236
operosus, Polycladolithus XI 202
operosus, Trochoaster XI 202
OPHIDIIDAE *XV 102*
Ophidion XV 99
sp. XV 100, XV 103
OPHIOBOLIDAE *XII 228*
Ophiobolus XII 228
lapidaris XII 224, XII 228
ophirense, Anthocyrtidium XX 28
ophirensis, Anthocyrtis XX 28
OPHTHALMIDIINAE *XI 273*
Ophiodesia XVI 129
Ophiomorpha XVII 93
Ophiraphidites XVI 125
annulatus XVI 129
cylindricus XVI 129
HADROS XVI 127, *XVI 128, XVI 134*
infundibuliformis XVI 125, XVI 126, XVI 130
ramosus XVI 129
tortuosus XVI 125
tuberosus XVI 129
opifex, Modiolus XIX 168
opima, Nonionella XI 298
Opimocythere
hazeli XVII 34
interrasilis XVII 34
Opisocardium XVI 7
optima, Navicula XX 52, XX 56
Orania fusulus XIX 81, XIX 86
Orbiculina compressa XI 278
orbicularis, Neoconorbina XI 286
orbicularis, Rosalina XI 286
ORBICULATUS, *Coccolithus* **XIX 20,** *XIX 32*
orbiculatus cf., Coccolithus XIX 22, XIX 32
Orbis XVI 7
orbis, Cyclococcolithus XI 24, XI 195
orbita, Vasticardium XVI 38
ORBITOIDACEA *XI 294*
Orbitolites marginalis XI 279
orbitoilitoides, Broeckina XI 278, XVI 94
orbitolitoides, Praesorites XI 278
Orbulina XIV 50
bilobata XIV 24, XIV 50, XIV 56, XV 10
suturalis XIV 50, XIV 56
universa XIV 24, XIV 50, XIV 56, XV 12, XV 22, XVI 94, XVI 146, XVIII 26
Orbulinoides
beckmanni XI 11
Orbulites marginalis XI 279
Oreas XIV 88
Oridorsalis westi XVI 94
Orionina XIV 145
bermudae XIV 145
bradyi XIV 145
vaughani XIX 145
vaughni XIX 139
ornata, Calyptraea XI 165
ornata, Calyptraea (Trochita) XI 164, XI 165, XI 166
ornata, Stylodicta XX 16
ornatissima, Hauerina XI 277
ornatum, Ctenidodinium XVIII 150
ornatus, Arachnoidiscus XX 42
ornatus, Micrantholithus XI 46, XI 49, XI 189, XI 212
orri, Attiliosa XIX 87
orri, Muricopsis XIX 87
Orthaulax XV 105
aguadillensis XIV 128, XV 110
altilis XV 108
gabbi XV 108
hernandoensis XV 112
inornatus XV 108
pugnax XV 108
orthia, Braarudosphaera XI 189
Orthocardium XVI 7
orthoceras, Cribroperidinium XII 186
orthoceras, Gonyaulacysta XII 185, XII 202
orthoceras, Gonyaulax XII 186
Orthocerina multicostata XIX 191
Orthokarstenia XIX 190
Orthomorphina XIX 191
orthoteichus, Cupanieidites XVII 29
Orthozygus aureus XI 224, XI 242
Oscillaria aureliana XIII 61
Oryzaria XVIII 20
boscii XVIII 20
oryzoides, Lithophaga XIX 170
Osculapollis
aequalis XVII 36
colporatus XVII 39
osculosa, Spongopyle XX 14, XX 16
osculosus, Spongodiscus XX 14
OSTARIOPHYSI *XV 96*
OSTEICHTHYES *XV 102*
ostentata, Yochelcionella XVI 72
OSTRACODA *XII 58, XIV 137, XIX 123, XIX 146*
Ostrea XIII 186, XV 74

borealis XV 44
haitensis XV 44, XVI 97, XVI 159
johnsoni XI 181
lisbonensis XI 4
nilssoni XV 51
plicatuloides XV 51
sellaeformis XI 181
tenuiplicata XV 50
Ostrea (Lopha) folioides XIII 190
ostrearum, Calotrophon XII 105, XII 112, XII 114, XII 116, XII 118, XII 120, XII 134
ostrearum, Murex XII 105, XII 133
ostrearum, Muricidea XII 105
ostrearum, Pseudosalpinx XII 106
ostrearum conradi, Calotrophon XII 109, XII 114
OSTREIDAE *XVII 103*
Otocheilus XIV 107
mississippiensis XIV 107
nereidis XIV 110
Otolithus XV 100
Otolithus (Sciaenidarum) intermedius XV 100
ovalis, Anadara XVII 102, XIX 61
ovalis, Ericsonia XI 25
ovalis, Pleurodon XVIII 161
ovalis, Xanthiopyxis XX 64, XX 66
ovata, Cytherella XII 92
Ovicardium XVI 8
oviedoiana, Valvulina XI 272
oxia, Nannodiella XVII 102
oxytata, Murex XIX 86
oxytata, Muricopsis XIX 86
OZANENSIS, *Bukryaster* **XII 166**

P

Pacambocythere campana XIX 148, XIX 155
pacata, Siltaria XVII 29
Pachyascus XVI 138
Pachycardium XVI 8
Pachycrommium guppyi XV 110
pachyderma, Aristerospira XIV 35
pachyderma, Globigerina XIV 18, XIV 35
pachyderma, Korystocysta XVIII 148
pachystirus, Dermomurex XI 127
pachystirus, Murex XI 130
pacifica, Puriana XII 72
pacifica cf., Thalassiosira XX 62, XX 64
pacificus, Sphenolithus XI 54, XI 232
Pagodula XII 118, XIV 131
Palaeocystodinium australinum cf. XVII 37
Palaeohystrichophora infusoriodes XVII 42
Palaeoperidinium XII 196
basilium XII 196, XII 216
deflandrei XII 196
deflandrei cf. XII 196, XII 216, XII 218
pyrophorum XVII 37
paleocenica, Interpollis XVII 39
Paleotetradinium silicorum XII 220
palmata, Acropora XIII 124, XIII 128
palmerae, Luvula XII 77
Palmoxylon
cellulosum XV 59
quenstedti XV 59
Palmula henbesti XII 148
paloverdensis, Cornutella XX 22
Palythoa
mammillosa XIII 130
sp. XIII 114
pamplomensis, Dimya XV 50
pamplomensis, Plicatula XV 50
panamense, Cardium XVI 40
panamensis, Protocardia XVI 40
PANAMICA, *Olssonella* **XII 35**, *XII 40*
Panamurex [see also Poirieria (Panamurex)] XI 124, XI 152, XII 102
panarium, Discolithina XI 31
Pandora trilineata XVII 104, XIX 108
PANDORIDAE *XVII 104*
pannea, Dichadogonyaulax XVIII 148
panucea, Deflandrea XII 194, XII 210, XVII 37
Panopaea XVIII 166
oblongata XVIII 167
Panope XVIII 166
parawhitfieldi XVIII 166
sp. indet. XVIII 166
Panopea XVIII 166
aldrovandi XVIII 166
CHIPOLANA XVIII 166, *XVIII 167*
goldfussi XVIII 165
whitfieldi XVIII 165
Panopeus herbstii XVII 114
PANSYRTA, *Astarte (Ashtarotha)* **XVI 165**, *XVI 166*
papillatum, Pemma XI 48, XI 51, XI 52, XI 191
Papillicardium XVI 8
papillosa, Morula XIX 64
papillosum, Cardium XVI 8
papillosum, Plagiocardium (Papillicardium) XVI 14
Papyridea XIII 164, XVI 8, XVI 18
apertum XIII 164
bulbosa XIII 158, XIII 165, XIII 178
harrimani XVI 8
MIOCICA *XIII 162*, **XIII 168**, *XIII 178*
MULTICOSTULA *XIII 158*, **XIII 169**, *XIII 178*
ringens XIII 164
soleniforme XIII 164
soleniformis XVI 20, XVI 22
transversum XIII 164
Paraalnipollenites confusus XVII 38
Paracardium doris XVII 48
paracastanea, Cytheromorpha XII 74, XIV 148, XIV 152
paracastanea, Leptocythere XII 74, XII 82, XIV 148
PARACYPRIDIDAE *XII 59, XIV 139*
Paracypris
choctawhatcheensis sp. cf. XIX 139
franquesi sp. cf. XIX 139
Paracytheretta
daniana XIV 154
karlani XII 86
Paracytheridea XII 68, XIV 142

nodosa XIV 142
tschoppi XII 69, XIV 143, XIV 148, XIX 139
sp. XII 68, XII 78, XIX 139
vandenboldi XIV 142
vandenboldi sp. cf. XIV 142, XIV 150
vanwessemi XIV 143
Paracytheris XII 59, XIV 139
choctawhatcheensis XII 59
franquesi XII 59
kaesleri XII 59
parapiculata XVII 34
polita XII 59
rosefieldiensis XII 59
sablensis XIV 139, XIV 146
sp. XII 59, XII 66
Paracytherois
ensiforme XII 76
ensiformis XII 76
paradisiaca, Volema XVI 149
paradoxa, Cytherura XII 64
Paradoxostoma XII 76, XIV 148
ensiforme XII 76, XII 78, XII 82
sp. XIV 148
PARADOXOSTOMATIDAE *XII 76, XIV 148*
PARADOXOSTOMATINAE *XII 76, XIV 148*
PARAGOULDIA XVIII 123
Parakrithe spp. XIX 139
Parakrithella XII 61
sp. XII 61, XII 74
paralatissimum, Cytheropteron XII 65
Paralia
biseriata XX 52
sulcata XX 52
Parallelodon XVIII 71
Paramya subovata XVII 104
Paranesidea XIV 139
bradyi sp. cf. XIV 139, XIV 146
parapiculata, Paracypris XVII 34
parasiensis major, Micrantholithus XI 51
Paraster
armiger XVIII 130
doderleini XVIII 135
floridiensis XVIII 135
parawhitfieldi, Panope XVIII 165
parile, Cardium (Trachycardium) XIII 156
parile, Trachycardium XIII 150, XIII 156, XIII 178
parisiense, Nemocardium (Discors) XVI 30
parisiensis, Micrantholithus XI 191
parisiensis, Quinqueloculina XVIII 6
parisiensis major, Micrantholithus XI 191
parkerae, Globigerinita XVIII 35
parkerae, Globigerinoides XVIII 34
parkerae, Prosphaeroidinella XV 12, XV 22, XVIII 26
parkeri occidentalis, Quinqueloculina XI 274
parkinsoniana, Ammonia XI 288, XVI 94
parkinsoniana, Rosalina XI 288
parkinsoniana, Rotalia XI 288
Parsonsidites conspicuus XVII 27
partschi, Murex (Bolinus) XI 153
parva, Dictyocha XX 90
Parvangulae XVI 82
Parvicardium XVI 8, XVI 18
commutatum XVI 14
pinnulatum XVI 38
Parvigenerina walshi XI 272
Parvilucina multilineata XVII 103
parvula, Braarudosphaera XI 187
parvula, Eouvigerina XVI 94
parvula, Textularia XI 272, XI 280
parvum, Cardium XVI 8
parvus, Distephanus XX 90, XX 92
parvus, Myrtaceidites XVII 29
parvus, Salixipollenites XVII 29
pascagoulaensis, Cyprideis XIX 146
pascagoulaensis sp. aff., Cyprideis XIX 150
Pascoella XVI 8
Patella
aculeata XI 166
equestris XI 170, XI 171
trochiformis XI 164
patricius, Conus XII 18
Patrocles XIV 88
patula, Purpura XIII 114
patulum, Cardium XVI 8
patulum, Nemocardium (Varicardium) XVI 34
patzcuaro cf., Candona XII 66, XII 93
paucicostatum, Cardium XVI 8
pauciloculata, Ammonia XVI 94
paula, Bolivina XI 282
pauli, Fusilatirus XIII 196
paupercula, Aspella XI 140
pauperculum, Cardium XVI 6
pauperculum varians, Aspella XII 45
pauperculus, Aspella XI 140
pauperculus, Aspella (Dermomurex) XI 140
pauperculus, Dermomurex XII 45
pauperculus, Dermomurex (Dermomurex) XI 138
pauperculus, Murex XI 138
pauxillus, Murex XIX 86
pauxillus, Muricopsis XIX 86
Pavonina miocenica XVI 94
PAVONININAE *XI 284*
paxillus, Oliva XVI 113
paxillus, Oliva (Omogymna) XVI 118
pazi, Murex XII 102
Paziella [see also Poirieria (Paziella)] XI 124, XIV 131, XVI 46
Pazinotus XIV 131, XVI 44
oliverai XIX 87
pebasae, Cytheridea XIX 152
pecketi, Marginulina XV 6
pecketi spinosa, Marginulina XV 6
peckiana, Quercus XIII 60
Pecten
eboreus darlingtonensis XVI 97
jeffersonius XVI 98
raveneli XIX 61
PECTINACEA *XV 35*
pectinata, Discolithina XI 31
pectinata, Lucina XIX 61
pectinata, Pontosphaera XI 28, XI 30, XI 32
pectinata, Stichopera XX 26
pectinatus, Discolithus XI 31
PECTINIDAE *XV 35, XVII 102*
PECTOCYTHERIDAE *XII 80*

Pectunculus XVI 8, XVII 17, XVIII 166
sulcatus XVI 165
Pediastrum XVII 30
pediculatus, Zygolithus XI 238
Pejona lajollaensis XV 124
pelagica, Coccosphaera XI 14, XV 14
pelagica, Hastigerina XIV 25, XIV 50, XIV 58
pelagica, Nonionina XIV 50
pelgica, Thalassiphora XVII 37
pelagica, Thoracosphaera XIX 42
pelagicus, Coccolithus XI 13, XI 14, XI 16, XI 22, XI 119, XI 194, XV 14, XV 26, XVII 31
pelagicus, Cylicargolithus XVIII 26
Pelagiella XVI 71
atlantoides XVI 73
PELECYPODA [see Bivalvia] *XVI 61, XVIII 67, XVIII 70*
pelicomorphus, Coccolithus XI 198
pellucida, Fissurina XI 279
pellucida, Trigona XII 42, XII 44
Pellucistoma XII 78
atkinsi XIV 152
atkinsi sp. aff. XIV 152
howei XII 78
magniventra XII 78, XII 86, XIX 139
Pelocypris zilchi XIX 154
peloronta, Nerita XVII 132
pelouatensis, Bursa XI 156
pelycomorphus, Coccolithus XI 29
Pemma XI 50, XI 190
angulatum XI 46, XI 50, XI 191
balium XI 190, XI 214
basquense XI 48, XI 50, XI 190, XI 192, XI 218
basquense crassum XI 46, XI 50, XI 52, XI 191, XI 218
basquensis XI 190, XI 191
bulbosus XI 48, XI 51, XI 52, XI 191
major XI 48, XI 51
papillatum XI 48, XI 51, XI 52, XI 191
rotundum XI 50, XI 52, XI 56, XI 190, XI 191
serratum XI 192, XI 222
sp. A XI 192, XI 212
snavelyi XI 190, XI 192
stradneri XI 50, XI 190, XI 192, XI 222
pendula, Melothria XIII 61
PENEROLIPIDAE *XVIII 18*
PENEROPLINAE *XI 277*
Peneroplis XI 277
bradyi XI 277, XI 288
carinatus XI 277, XI 288
pertusus XI 278, XI 288
protea XI 278
proteus XI 278, XI 290, XVI 94
Peneroplis (Monalysidium) polita XI 278
Penicillus XIII 116
peninsularis, Basterotia (Basterotia) XVI 158
pensylvanica, Linga XIX 61
pentagona, Dictyocha XX 86, XX 88
pentagonus, Cyclostremiscus XVII 100
pentagonus, Distephanus XX 90
pentaradiata cf., Deflandrea XII 194, XII 214
pentaradiatus, Discoaster XI 58, XI 120, XI 198, XV 14, XV 26, XVI 146, XVIII 26
pentas, Spongaster XX 8
Pentaster lisbonensis XI 192, XI 224
peramabile, Cardium XVI 7
peramabile, Nemocardium (Microcardium) XVI 30
peramabilis, Cardium XVI 7
perarmatum, Infundibulum XI 164
Peratocytheridea XIX 139
perattica, Krithe XVII 34
perbrevisformis, Chione (Chione) XVIII 75
perchardei, Typhis XVII 124
PERCIFORMES *XV 103*
perdecora cf., Loxoconcha XVII 34
perdurum, Lithostromation XI 202, XI 236, XV 14, XV 28
peregrina, Stichocorys XX 26
perexilis, Turbinella XIII 195
Periarchus
floridanus XII 141, XVIII 130
lyelli XI 181, XII 141
lyelli floridanus XII 141
Perichlamydium
scutaeforme XX 14
venustum XX 14
PERIDINIACEAE *XII 191*
PERIDINIALES *XII 181, XVIII 148*
Peridinium
basilium XII 196
delitiense XII 190
Periploma margaritaceium XVII 104
PERIPLOMATIDAE *XVII 104*
Periptera XX 54
tetracladia XX 56, XX 58
Peripyramis circumtexta XX 20
Perisphincta XIV 88
Perisphinctina XIV 88
Perissocytheridea XIX 155
bicelliforma XIX 139
cytheridellaformis XIX 152, XIX 155
excavata XII 70, XII 93
rugata XII 93, XII 97
subrugosa XIX 139, XIX 148, XIX 155
PERISSOCYTHERIDEINAE *XIX 155*
Peristernia
filicata XII 110
nodulosa XII 111, XII 133
Peristichia agria XVII 102
perlatum, Ponticeras XVII 49
Perna XIX 160
CRAURA XIX 160, *XIX 162*
magellanica XIX 160
perna XIX 161
solereperta XIX 161
perna, Perna XIX 161
perna, Mya XIX 160
perplexus, Cantharus (Pseudosalpinx) XII 106
perplexus, Discoaster XV 14, XV 26
perpolitus, Discoaster XIX 9
perprocera, Marginulina XVI 94
persimilis, Volvulella XVII 102
perspectiva alumensis, Trigonostoma XII 44
perspectivum, Sinum XVII 101
perturbatrix, Enaeta XIV 118

perturbatrix, Lyria (Enaeta) XIV 118, XIV 120
perturbatrix, Mitra (Strigatella) XIV 118
pertusa, Virgulina XIII 140
pertusa, Virgulinella XIII 140
pertusus, Nautilus XI 278
pertusus, Peneroplis XI 278, XI 288
Peruarca XVIII 68, XVIII 71
Perucardia XVI 8
peruviana, Cardium XVI 8
peruviana, Septocardia XVI 16
perversa nigrocincta, Triphora XVII 100
perversum pulleyi, Busycon XVII 101
pessoae, Agnocardia XVIII 42
pessoae, Cardium (Trachycardium) XVIII 42
Petaloconchus XVI 97
sculpturatus XVI 97
petalosus, Toweius XIX 28, XIX 38
petosus, Athleta XV 73
Petricola XII 47, XII 163
costata XII 47, XII 163
pholadiformis XVII 104
Petricola **(PETRICOXENICA)**
CONCORALLA XII 47, *XII 48, XII 163*
HOERLAE XII 163, *XII 164*
Petricolaria XII 47, XII 163
PETRICOLIDAE *XII 45, XII 163, XVII 104*
PETRICOXENICA XII 47, *XII 163*
petrijacob, Regadrella XVI 137
Pettersia XVIII 68, XVIII 71
petterssoni, Diartus XX 6
Phacoides megameris XVII 135
Phacoides (Pseudomiltha) megameris XVII 135
Phacorhabdotus
formosus XVII 34
sculptilis XVII 34
PHAEODARIA *XX 34*
PHAEOGROMIA *XX 34*
PHAEOPHYTA *XIX 18*
phagon, Poirieria (Panamurex) XII 103, XII 112
Phalium XIX 177
aldrichi XIX 177
granulatum XVII 101
Phalium (Semicassis) aldrichi XIX 177
Pharamum XIV 88
Pharciceras amplexum XVII 49
phelani, Oligopygus XVIII 128, XVIII 131
phillipiana, Attiliosa XIV 132
philippiana, Attiliosa XII 111, XII 120, XII 126, XIV 131
philippiana, Calotrophon (Attiliosa) XII 120
philippiana, Coralliophila XII 111, XII 120
philippiana, Muricidea XII 111, XII 120
philippinense, Cardium XVI 38
phlegon, Nannippus XI 111
Phlogocardia XIII 154, XVI 8
PHLOGONIIDAE *XX 18*
phlyctaena, Cardium (Cerastoderma) XIII 152
PHOLADIDAE *XVII 104*
pholadiformis, Petricola XVII 104
Phonemus XIV 88
Phormostichoartus XX 32
corbula XX 30, XX 32
fistula XX 30, XX 32
sp. XX 30, XX 34
Phorticium XX 16
polycladium XX 16, XX 18
Phos XV 114
phosphoritica, Deflandrea XII 191
Phractocytheridea ruginosa XVII 34
phragmites, Exochosphaeridium XII 185
Phyllacanthus XII 143
Phyllocoma XI 122
Phyllonotus XI 153
Phymosoma XII 143, XVIII 73
Physocypria XIV 155, XIX 147
fadeewi XIV 156
pustulosa XIV 155
pustulosa sp. cf. XIV 154, XIV 155
pica, Cittarium XIII 114
PICOUINA XVIII 14
mississippiensis XVIII 10, XVIII 14
pictum, Laevicardium XIX 61
pictus, Donax XVI 7
pilata cf., Wetzeliella XII 202, XII 220
pilosus, Coscinodiscus XX 46, XX 52
Pilsbrytyphis XVII 128
Pinna sp. XIII 118
pinnatus, Murex XVI 46
PINNIDAE *XVII 102*
Pinnocaris XVI 77
sp. C XVI 79
wellsi XVI 79
Pinnularia crabro XX 48
pinnulatum, Parvicardium XVI 38
Pinus XX 9
Pistillipollenites mcgregorii XVII 30
PITTORUM, TORQUIFER XVI 150
placacantha, Systematophora XII 224, XII 228
placacanthum, Baltisphaeridium XII 228
placacanthum, Hystrichosphaedirium XII 228
placomorpha, Reticulofenestra XI 29, XI 197, XI 198
placomorphus, Coccolithus XI 198
Plagiobrissus
dixie XVIII 131
grandis XVIII 134
Plagiocardium XVI 8
Plagiocardium (Maoricardium) XVI 18
spatiosum XVI 18
Plagiocardium (Papillicardium) XVI 18
papillosum XVI 14
Plagiocardium (Plagiocardium) XVI 18
granulosa XVI 14
plana, Crepidula XVII 101
plana, Discolithina XI 31
plana, Pontosphaera XI 28, XI 31, XI 36
Planaria XVI 58
planata, Vaginulinopsis XVI 94
planciana, Triloculina XI 276
Planera thompsoniana XVII 28
Planicardium XVI 8
Planimodiola XIX 166
Planispira auriculata XI 273
planoconvexa, Pseudoticinella XI 306
Planolites XVIII 108
Planorbis XVI 159, XVIII 163

planorbis, Cornuspira XI 273
planorbis, Cyclogyra XI 273, XI 280
Planorbulina XI 294
acervalis XI 294
mediterranensis XI 294, XVI 94
PLANORBULINIDAE *XI 294*
PLANTAE *XI 12, XI 187, XIX 18*
planulata, Mysella XIX 108
Planulina
cocoaensis XII 148
faveolata XVI 92
mera XVI 94
planus, Discolithus XI 31
Platanus
occidentaloides XVII 29
sp. XVII 28
Platycarya XVII 27
platycaryoides XVII 29
platycaryoides, Platycarya XVII 29
PLATYCOPINA *XII 92, XIV 156*
PLATYCOSTATA, *Gouldia* **(PARAGOULDIA) XVIII 123,** *XVIII 125*
plebeius, Tagelus XVII 104
Plectofrondicularia inglisiana XII 141
plectopons, Zygodiscus XIX 9
Plectronoceras XVI 71
plena, Brachycythere XVII 34
plena, Trudopollis XVII 38
Pleuriocardia (Dochmocardia) XVI 18, XVI 22
Pleuriocardia (Pleuriocardia) XVI 18, XVI 22
Pleurocardia XVI 8, XVI 40
Pleurochrysis scherffelii XI 12
Pleurodesma floridana XVI 161
Pleurodon XVIII 161
gunteri XVIII 162
ovalis XVIII 161
woodii XVIII 162
PLEURONECTIFORMES *XV 103*
Pleurotoma XV 6
Plicapollis usitatus XVII 36
plicaris, Oliva XVI 107
plicata, Gangamocytheridea XIX 139
plicatella, Raeta XVII 103
Plicatopollis cretacea XVII 36
Plicatula
gibbosa XVII 102
HUNTERAE *XI 106,* **XI 108,** *XVI 98*
inezana XI 108
pamplomensis XV 50
plicatuloides XV 51
sigillina XV 51
spondylopsis XI 108
PLICATULACEA *XV 35*
PLICATULIDAE *XI 108, XV 35, XVII 102*
plicatuloides, Dimyodon XV 51
plicatuloides, Ostrea XV 51
plicatuloides, Plicatula XV 51
plicatus, Cocsinodiscus XX 46, XX 52
plicatus, Spondylus XI 108
Plinthosella XVI 130
plummerae, Ellipsonodosaria XVII 35
plumula, Lithophaga XIX 170
pluriradiatum, Cardium XVI 8
plusculmensis aff., Hermanites XVII 34
plutonis, Nerita XVII 131
PODOCOPIDA *XII 58, XIV 137, XIX 146*
PODOCOPINA *XII 58, XIV 137, XIX 146*
Pododesmus rudis XIX 55
Podosira
glacialis XX 56
hormoidesi XX 56
poeyana, Polystomella XI 292
poeyana, Quinqueloculina XI 274, XI 284
poeyanum, Cribroelphidium XI 292, XI 298
poeyanum, Elphidium XI 292
Poirieria XI 97, XI 124, XII 102, XII 118, XIV 131, XVI 46
Poirieria (Panamurex)
alaquaensis XII 103
carnicolor XII 103
clarksvillensis XI 152, XII 103
dubitalis XII 103
fusinoides XII 103
gabbi XII 103
gatunensis XII 102
gilletteorum XI 152
heilprini XII 102
hutchisoni XII 103, XII 112
laccapoia XI 83, XI 152, XII 104
lychnia XII 103
macneili XII 102
mauryae XII 102, XII 112
phagon XII 103, XII 112
velero XII 103
Poirieria (Paziella) nuttingi XII 102
Poirieria (Pazinotus) bowdenensis XII 110
Polinices duplicatus XVIII 117, XIX 61
polita, Cytherella XII 93
polita, Paracypris XII 59
polita, Peneroplis (Monalysidium) XI 278
politum, Monalysidium XI 278
polyacantha, Larnacantha XX 18
polyacantha, Lithocarpium XX 18
polyacantha, Stephanogonia XX 60
polyactis, Dictyocha XX 90
polyactis, Distephanus XX 90, XX 92
polycladium, Phorticium XX 16, XX 18
Polycladolithus
operosus XI 202
stellaris XI 55
POLYCYSTINA *XX 12*
Polydora XVII 112
polygona, Quinqueloculina XI 274, XI 284
Polylepidina gardneri XI 181
polymorpha, Andalusiella XVII 37
polymorpha, Mesocena XX 94
POLYMORPHINIDAE *XI 279*
POLYMORPHININAE *XI 279, XVIII 18*
polymorphus, Hemiaulus XX 50, XX 56
Polyopesia XVI 138
POLYPLACOPHORA *XVI 56, XVI 61*
Polystira tellea XI 88
Polystomella
advena XI 290
poeyana XI 292
sagra XI 292

subnodosa XI 290
Polytretra XVI 125
Polytretia XVI 129
Pomatodelphis inaequalis XVII 71
ponderosa, Noetia XVII 102
Ponticeras perlatum XVII 49
PONTOCYPRIDIDAE *XII 60*
Pontocythere ashermani XII 62, XIV 141, XIX 134
pontoni, Fursenkoina XI 296, XVI 94
pontoni, Virgulina XI 296
Pontosphaera XI 30
bigelowi XI 45, XI 187, XIX 40
cribraria XI 206
multipora XI 28, XI 30, XI 32, XI 208
ocellata XI 34
pectinata XI 28, XI 30, XI 32
plana XI 28, XI 31, XI 36
pulcher XI 35
pulchra XI 31
rothi XI 206
syracusana XI 30
vadosa XI 30, XI 208
versa XI 31, XI 32, XI 36, XIX 40
PONTOSPHAERACEAE *XI 29, XI 206, XIX 40*
popei, Chrysalidinella XVI 94
poppelacki, Ranella XI 96, XI 98, XII 31
PORIFERA *XIII 118*
Porites XIX 172
asteroides XIII 122
porites XIII 122, XIII 128
porites, Porites XIII 122, XIII 128
Porodiscus
circularis XX 16
microporus XX 13
Poroepondides lateralis XVI 94
Porosira XX 56
glacialis XX 56, XX 58
porphyria, Voluta XVI 107
porrecta, Bolivina XI 296
porrectum, Loxostomum XI 296
porulosum, Cardium XVI 7
porulosum, Cardium (Orthocardium) XVI 18
postdorsoalata, Loxoconcha XIV 146
postdorsoalatum, Loxocorniculum XIV 146, XIV 152
posterotruncata, Argilloecia XII 60, XII 66, XIX 138
posti, Oliva XVI 112
Postligata XVIII 67
aventi XVIII 68
crenata XVIII 68
monroei XVIII 68
schalki XVIII 68
postornata, Cytheridella XIX 154
Potamides suprasulcatus XII 14, XVI 159
Potamocypris XIX 148
schubarti XIX 148
schubarti sp. aff. XIX 148
sp. XIX 148
Potamomya XVI 158
Poweria XI 133
Praeacanthochiton XVI 65
cooperi XVI 67
praebergonii, Rhizosolenia XX 58, XX 60
PRAECARDIIDAE *XVII 48*
PRAECARDIOIDA *XVII 48*
PRAECIPUUS, *Conus* **XII 20,** *XII 22*
praeconvexa, Thalassiosira XX 62, XX 64
praecursorius, Cibicides XVII 35
praelaevigata, Turbinella XVIII 52
praeovoidea, Turbinella XVIII 47
praeovoideus, Xancus XVIII 52
praepaleacea, Coscinodiscus XX 58
praepaleacea, Cussia XX 58
praepaleacea, Rossiella XX 54, XX 58
proavoideus, Xancus XVIII 52
praepumilio, Globanomalina XIV 52
praepumilo, Pseudohastigerina XIV 52, XIV 58
Praesorites orbitolitoides XI 278
Pratulum XVI 8
PRATULUM, *Pygmaepterys* **XVI 49,** *XVI 50*
prava, Transveropontis XI 222
Pravoslavlevia XIV 88
pravoslavlevia, Saracenaria XIV 86
Praxis XVIII 163
precursor, Typhis XVII 125
Prediscosphaera XIX 34
cretacea XIX 34, XIX 36
decorata XIX 34
Preophidion stintoni XV 100, XV 102
prima, Basterotia XVI 160
primalis, Pulleniatina XVIII 26, XVIII 34
primitiva, Bolivina XI 284
primitiva, Sagrina XI 284
primus, Amaurolithus XVIII 29, XVIII 35
primus, Ceratolithus XI 118, XVIII 35
princeps, Conus XII 28
PRINSIACEAE *XIX 36*
Prinsius XIX 36
dimorphosus XIX 26, XIX 36
martinii XIX 36
martinii cf. XIX 22, XIX 28, XIX 38
Probeloceras lutheri XVII 49
pristipleura, Cardium (Trachycardium) XIII 164
problema, Guttulina XVII 35
PROBLEMATICA *XII 145, XII 157, XIII 135*
proboscidiala, Cytheridea (Haplocytheridea) XIV 140
proboscidiala, Haplocytheridea XIV 140
proboscidium, Granocardium (Granocardium) XVI 14
procerum, Cardium XVI 7
procerum, Trachycardium (Mexicardia) XVI 20, XVI 28
procerus, Micrantholithus XI 46, XI 49, XI 189, XI 216
Proconodontus muelleri XVI 76
producta, Aspella XI 125
producta, Krithe XII 60
producta cf., Krithe XII 60, XII 74
producta, Ranella XI 126
productum, Cardium XVI 38
Proeuplectella fragilis XVI 137
proficua, Semele XVII 104
Profulvia XVI 8
profunda, Cornutella XX 22

profundus, Araliaceoipollenites XVII 29
PROLIXUS, *Chicoreus (Chicoreus)* **XI 88**
Proparacytheridea acuminata XIX 155
propebanneiana, Protocardia (Tendagurium) XVI 30
propebanneianum, Cardium XVI 8
propeciliare, Acanthocardia XIII 146, XIII 152, XIII 178
propeciliare, Cardium XIII 152
propeciliare, Cardium (Acanthocardia) XIII 152
propeciliare, Cardium (Trachycardium) XIII 152
propevenusta, Cancellaria XVI 97
propinqua, Macrocyprina XII 59, XIX 139
Prorastomas sirenoides XIV 161
Proscutella mississippiensis XI 181
PROSOBRANCHIA *XI 132, XII 3, XII 105, XV 118*
Prosphaeroidinella
parkerae XV 12, XV 22, XVIII 26
Protarca XVIII 68, XVIII 71
protea, Peneroplis XI 278
Proteacidites sp. XVII 36
protenus, Chiphragmalithus XIX 32
protenus, Neococcolithes XI 70, XIX 32, XIX 40
protenus, Zygolithus XIX 32
Proteoconcha XIV 145
multipunctata XIV 145, XIV 150
proteus, Peneroplis XI 278, XI 290, XVI 94
protexta, Strioterebrum XVIII 64
PROTOBIONTA *XIX 18*
Protocardia XV 39, XVI 8
panamensis XVI 40
Protocardia (Brevicardium) XVI 20
fragilis XVI 32
Protocardia (Cryptocardia) XVI 20
Protocardia (Globocardium) XVI 20
rothpletzi XVI 32
sphaeroidea XVI 32
Protocardia (Leptocardia) XVI 20
subquadrata XVI 30
Protocardia (Pachycardium) XVI 20
spillmani XVI 30
Protocardia (Protocardia) XVI 20
hillana XVI 30, XVI 32
Protocardia (Tendagurium) XVI 20
propebanneiana XVI 30
Protocardia (Yokoyamaina) XVI 20
hayamii XVI 32
PROTOCARDIINAE *XVI 12, XVI 20*
Protocytheretta XII 86, XIV 154
danaiana XIV 154
daniana XIV 154
karlani XII 86, XII 88, XII 90
LOUISIANENSIS XII 90
montezuma XII 88
montezuma **LOUISIANENSIS XII 88,** *XII 90*
pumicosa XII 86, XIV 154
reticulata XII 86, XII 88
Protolenus XVI 73
PROTOZOA *XII 228*
proxima, Nucula XIX 108
proximus, Strombus XV 110
PRYMNESIALES *[sic] XI 12*
Psammoscene XVIII 158
Pseudobolivina XI 272
walshi XI 272, XI 280
PSEUDOBOLIVININAE *XI 272*
pseudobulloides, Globorotalia XIX 11
Pseudocandona XIX 147
antilleana XIX 147
sp. XIX 147
Pseudocardia XVI 41
Pseudocardita XVI 43
Pseudocardium XVI 41
pseudocarteri, Coccolithus XI 197
Pseudocucullaea XVIII 71
Pseudocythere fragilis aff. XII 70, XII 93
Pseudoemiliania lacunosa XI 120, XV 13, XV 28, XVI 146, XIX 130
Pseudoeunotia XX 56
doliolus XX 56, XX 58
pseudofibula, Dictyocha XX 86
pseudofibula, Distephanus XX 88, XX 92
pseudofiliformis, Gaudryina XIX 186
Pseudoglandulina
multicostata semicostata XIX 191
pygmaea XVII 35
Pseudohastigerina XIV 52
praepumilo XIV 52, XIV 58
Pseudolaesopollis ventosa XVII 29
Pseudoliva XV 73
pseudomenardii, Globorotalia XIX 11
pseudomenardii, Truncorotataloides (Planorotalites) XII 237
Pseudomiltha
floridana XVIII 103
gigantea XVII 136
haitensis XVII 135
megameris XVII 135
pseudomiocenica, Globorotalia XV 11
Pseudonodosaria XI 279
torrida XI 279
Pseudoparella exigua cf. XVII 35
Pseudophragmina XII 141
Pseudophragmina (Proporocyclina) XII 143, XVIII 73
Pseudoplicapollis
limitata XVII 39
serena XVII 39
Pseudopsammocythere vicksburgensis XIX 139
Pseudopterogorgia XIII 113
Pseudopyxilla XX 56
americana XX 56, XX 58
dubia XX 56, XX 58
pseudoradians, Sphenolithus XI 54, XI 236
Pseudosalpinx XII 105
ostrearum XII 106
pseudostriata, Cytheura XIV 142
Pseudoticinella
multiloculata XI 306
planoconvexa XI 306
pseudoumbilica, Reticulofenestra XI 29, XI 119, XV 16, XV 28, XVI 146, XVIII 26, XIX 130
Pseudovacuopollis involutus XVII 36
Pteria XIII 113
Pterocorys

bicornis XX 26
hirundo XX 22
splendens XX 24
PTEROCORYTHIDAE *XX 28*
Pteropurpura XII 120, XVI 47
virginiae XI 154
Pterospermella XX 9
Pterotyphis vokesae XI 96
Pterygocythereis XII 85, XVI 86
alophia XIX 139
americana XII 85, XII 90
cornula americana XII 85
inexpectata XIX 139
miocenica XII 85, XII 90
sp. XIX 139
PTERYGOCYTHERIDINAE *XII 85*
Pterynotus XI 97, XI 124, XII 118, XII 120, XVI 46
tripterus XVI 52
Pterynotus (Pterochelus) XI 97
Pterynotus (Pygmaepterys) XVI 46
Ptiloncodus XVI 62
simplex XVI 65
puella, Spongocore XX 14
puer, Spongocore XX 14, XX 16
puertoricensis, Typhis XVII 124
Pugilina XVI 149
fasciata XVI 149
pugnax, Orthaulax XV 108
pugnans, Vasum XV 113
pugnus, Vasum XV 110, XV 113
pulaskensis, Gryphaeostrea XVII 33
pulchella, Dictyocha XX 86, XX 88
pulchella, Lyria XIV 112
pulchella, Lyria (Lyria) XIV 112, XIV 118
pulchella, Lyria (Sannilyria) XIV 112
pulchella, Voluta XIV 112
pulchella soror, Lyria XIV 112
pulchella primitiva, Bolivina XI 284
pulchella primitiva, Sagrina XI 284, XI 292
pulchellum, Nemocardium (Pratulum) XVI 34
pulchellus, Cestodiscus XX 43
pulcher, Discolithus XI 35, XI 220
pulcher, Pontosphaera XI 35
pulcher, Transversopontis XI 35
pulcheroides, Discolithina XI 35, XI 222
pulcheroides, Discolithus XI 35, XI 220
pulcheroides, Transversopontis XI 35, XI 38, XI 222
pulchra, Alveolina XI 279
pulchra, Borelis XI 279
PULCHRA, *Deflandrea* **XII 194,** *XII 214*
pulchra, Discolithina XI 35, XI 220
pulchra, Pontosphaera XI 31
pulchra, Siphonina XI 286, XVI 94
pulchra, Syracosphaera XI 119
pulchra, Transversopontis XI 35, XI 36, XI 42, XI 222
pulchra sp. aff., Cytherella XIX 139
pulchricostatum, Vepricardium XVI 8, XVI 14, XVI 16
pulchriporus, Discolithus XI 39, XI 222
pulchriporus, Transversopontis XI 38, XI 39, XI 42, XI 222
Pullenia XIX 182
obliquiloculata XIV 58
quinqueloba XVII 35
sphaeroides obliquiloculata XIV 58
subcarinata XVI 94
Pulleniatina XIV 58
finalis XVI 94
obliquiloculata XIV 28, XIV 58, XVI 84, XVI 146
obliquiloculata finalis XIV 58, XIV 66, XIV 68
obliquiloculata obliquiloculata XIV 58
primalis XVIII 26, XVIII 34
pulleyi, Cativella XIX 155
Pulvinulina
menardii tumida XIV 68
scitula XIV 66
tumida flexuosa XIV 62
pumicosa, Cythere XII 88, XIV 154
pumicosa, Protocytheretta XII 86, XIV 154
pumilio, Globanomalina XVIII 35
Pumilocytheridea XI 60
ayalai XII 60
sandbergi XII 60
sandbergi cf. XII 60, XII 70
punctata, Fursenkoina XVI 94
punctata, Thalassiosira XX 62, XX 66
punctatocostata, **TAPPANELLA** *XVIII 10, XVIII 12*
punctatus, Auliscus XX 42, XX 48
punctostriatus, Acteon XVII 102
punctulata, Daktylethra XI 10, XI 230, XI 238
Punicum exile XIII 61
Puriana XII 69, XIV 145, XVI 86
KRUTAKI XII 70, *XII 78*
mesocostalis XII 72
pacifica XII 72
rugipunctata XII 69, XII 78, XIV 145, XIV 150, XIX 134
rugipunctata gatunensis XIX 139
sp. XIX 139
purisubrhomboidea, Loxoconcha XII 72
purisubrhomboidea aff., Loxoconcha XII 72, XII 82
PURPERAE, *Cytheridea XIX 148,* **XIX 150**
purperi purperi, Cyprideis XIX 152
Purpura XIII 194
alata XVI 46
patula XIII 114
purpurens, Spatangus XVIII 134
purpurispina, Murexsul XIX 87
purpurispina, Muricopsis XIX 87
pusilla, Globorotalia XIX 11
pusilla, Tectonatica XVII 101
pusilla, Truncorotataloides (Planorotalites) XII 237
pustula, Basterotella XVI 157
pustulosa cf., Cypria XIV 155
pustulosa, Physocypria XIV 155
pustulosa sp. cf., Physocypria XIV 154, XIV 155
Pycnodesma XVI 130
pycnopleura, Falsilyria XIV 124, XIV 126
pycnopleura, Lyria XIV 126
pycnopleura eocenia, Lyria XIV 120

pygmaea, Aspella XI 125
pygmaea, Pseudoglandulina XVII 35
pygmaea, Ranella XI 126
Pygmaepterys XVI 48
alfredensis XVI 52
alfredensis cf., XVI 52
DREZI XVI 48, *XVI 50*
funafutiensis XVI 52
GERMAINAE *XVI 48*, **XVI 50**
maraisi XVI 52
PRATULUM XVI 49, *XVI 50*
Pylodexia uvula XIV 56, XV 12
PYLONIIDAE *XX 16*
pyramidalis, Aspella XI 126, XI 134
pyramidalis, Globigerinoides XVI 94
pyramidalis, Ranella XI 125
Pyramidella crenulata XVII 102
PYRAMIDELLIDAE *XVII 102*
Pyrazisinus harrisi XI 154
Pyrgo XI 275
carinata XI 275, XI 284, XVI 92
comata XI 275
nasuta XVI 94
subsphaerica XI 275, XI 284
vespertilio XVI 94
pyriforme, Eudolium XIX 178
PYRMNESIALES *XI 187, XIX 18*
pyrophorum, Palaeoperidinium XVII 37
PYRRHOPHYTA *XII 180*
pyrula, Nodosaria XVI 94
Pyxilla
barboi XX 58
dubia XX 56

Q

Quadracythere compacta XIX 139
quadragenarium, Cardium XVI 6
quadragenarium, Trachycardium (Dallocardia) XVI 20, XVI 40
quadrangula, Larcospira XX 16, XX 18
quadrangula, Mesocena XX 94, XX 98
quadrata, Anisodonta (Basterotia) XVI 158
quadrata, Basterotia XVI 160
quadrata, Corbula XVI 160
quadrata, Venericardia XVI 41
quadratus, Chiphragmalithus XI 9
quadricostulata, Fissurina XI 280
quadricostulata, Lagena XI 280
quadrilobata, Globigerina XIV 44, XV 12
quadrilobatus quadrilobatus, Globigerinoides XIV 22, XIV 44, XIV 50, XV 12, XV 18, XVI 145
quadrilobatus sacculifer, Globigerinoides XIV 22, XIV 46, XIV 52, XV 12, XV 18, XVI 146, XVIII 30
quadriperforata, Ericsonia XI 196
quadrispiralis, Strioterebrum XVIII 62, XVIII 64
quadrispiralis, Terebra (Strioterebrum) XVIII 64
quadrupla, Ammopemphix XVIII 157
quadrupla, Urnula XVIII 157
queenslandica, Myona? XVI 76
quenstedti, Palmoxylon XV 59
Quercoidites
inamoenus XVII 29
microhenricii XVII 28
Quercus
andromeda XIII 60
bumeliaefolia XIII 60
carpenterii XIII 60
peckiana XIII 60
rhombifolia XIII 60
quilonica, Tritonalia XI 129
quilonicus, Dermomurex XI 127
quinquangellus, Distephanus XX 90
quinqueloba, Pullenia XVII 35
quinqueloba, Globigerina XIV 19, XIV 35
Quinqueloculina XI 6, XI 274, XIX 182
agglutinans XI 274
aubergiana XI 274
bicostata XI 274, XVI 92
bidentata XI 274
bosciana XI 274, XI 280
byramensis XVIII 8
collumnosa XI 274
compta XVI 92
funafutiensis XI 274, XI 282
fusca XI 271
garrettii XVI 94
lamarckiana XI 274, XI 284
occidentalis XI 274
parisiensis XVIII 6
parkeri occidentalis XI 274
poeyana XI 274, XI 284
polygona XI 274, XI 284
sabulosa XVI 94
saxorum XVIII 5
secans XI 275, XVIII 10
seminulum XI 274, XVIII 10
subpoeyana XI 275, XI 284
tessellata XVIII 5
tricarinata XI 275
tuberculata XVIII 6, XVIII 12
QUINQUELOCULININAE *XI 273*
quinqueramus, Discoaster XI 115, XI 120
quinquiesperforata, Mellita XIX 53

R

racemosa, Laguncularia XII 107
radians, Lucina XIX 61
radians, Siderastrea XIII 118
radians, Sphenolithus XI 55, XI 56, XI 232, XI 234, XI 244
radians, Trochita XI 165
radians, Trochus XI 164
radiata, Dimya XV 50
radiata, Fissurina XI 280
radiata, Fissurina (Produttine) XI 280
radiata takii, Dimya XV 50
radiatus, Coscinodiscus XX 46, XX 54

radiatus, Trochoaster XI 56, XI 58
Radimella XIV 144
confragosa XIV 144, XIV 150, XIX 139
floridana XIV 143
RADIOLARIA *XX 11*
radula, Cardium XVI 38
radula, Murex XIX 86
radula, Muricopsis XIX 86
radula, Neritopsis XI 103
Raeta plicatella XVII 103
rafinesquiana, Dyopteris XIII 61
ramosa, Hystichosphaera XII 189
ramosa granosa, Hystrichosphaera XII 190
ramosum, Xanthidium XII 189
ramosus, Ophiraphidites XVI 129
ramosus granosus, Spiniferites XII 190, XII 208
ramosus granomembranaceous, Spiniferites XVII 37
ramosus membranaceus, Spiniferites XII 190
ramosus multibrevis, Spiniferites XII 190
ramosus ramosus, Spiniferites XII 189, XII 208
Ramulina globulifera XVI 94
Ranella XI 96, XI 124
alata XI 96
anceps XI 124
acuticostata XI 125
poppelacki XI 96, XI 98, XII 31
producta XI 126
pygmaea XI 126
pyramidalis XI 125
subanceps XI 125
Rangia
cuneata XII 247, XV 55, XVII 103, XVIII 108
flexuosa XVII 103
RAPUNCULUS, *Conus* **XII 21**, *XII 22*
raulini, Dimya XV 50
raveneli, Pecten XIX 61
reclivata, Neritina XVII 100
recta, Rhabdosphaera XI 226
rectangularis, Caudites XIX 138
rectispina, Cardium XVIII 43
Rectobolivina XI 282
advena XI 282, XVI 92
Rectoglandulina torrida XI 279
rectus, Blackites XI 40, XI 226
recurvus, Isthmolithus XI 11
redondoensis, Theocyrtis XX 26
redondoensis, Theocorys XX 26
redondoensis sp. cf., Theocorys XX 26
reevei, Lyria (Enaeta) XIV 120
refulgens, Cibicides XI 294
Regadrella
petrijacob XVI 137
TRABECULA *XVI 130* **XVI 136**
regina, Turbinella XVIII 47
reginum, Lithostromation XI 204, XI 236
reginus, Marthasterites XI 204
regius, Murex XIX 168
Regozara XVI 8
olivifer XVI 8
reinhardtii, Markalius XIX 28, XIX 36
reinholdii, Nitzschia XX 8, XX 54, XX 58
Reophax XI 271
nana XI 271, XI 280
Repandocosta sp. A XVII 34
repexa, Megacythere XIX 139
reticularis, Bombacacidites XVII 38
reticularis, Oliva XVI 109
reticularis trochala, Oliva XVI 112
reticulata, Cancellaria XII 34, XVII 101
reticulata cf., Cancellaria XII 33, XII 36
reticulata, Cyclococcolithina XI 195, XI 230
reticulata, Cytheretta XII 86
reticulata, Gephrocapsa XI 119, XV 16, XV 28, XVIII 26
reticulata sp. cf., Gephrocapsa XV 5
reticulata, Helicopontosphaera XI 214, XI 234
reticulata, Helicosphaera XI 214
reticulata, Protocytheretta XII 86, XII 88
reticulata, Voluta XII 33
reticulata adelae, Cancellaria XII 34
reticulatum, Cribrocentrum XI 195
reticulatus, Cyclococcolithus XI 195
Reticulofenestra XI 28, XI 197
bisecta XI 197, XI 228
callida XI 197, XI 240
caucasica XI 28, XI 29, XI 197, XI 198
coenura XI 26, XI 28
dictyoda XI 196, XI 197
hillae XI 197, XI 228
placomorpha XI 29, XI 197, XI 198
pseudoumbilicata XI 29, XI 119, XV 16, XV 28, XVI 146, XVIII 26, XIX 130
samodurovi XI 198
scissura XI 197
umbilica XI 26, XI 29, XI 197, XI 228
reticulum, Lithostromation XI 204
Retitrescolpites anguloluminosus XVII 30
Retitricolpites sp. XVII 36
retrostriata, Buchiola XVII 47, XVII 48
retusa, Lunulicardium XVI 7
retusum, Cardium XVI 7
retusum, Fragum (Lunulicardium) XVI 22, XVI 24
Reussella XI 284, XIX 182
atlantica XI 88, XI 284
miocenica XVI 94
spinulosa atlantica XI 284
reversa, Krithe XII 61
Rexmela XVI 152
Rhabdolithes XI 44
creber XI 41, XI 224
gladius XI 45
rudis XI 38, XI 45
tenuis XI 44, XI 228
Rhabdolithus
costatus XI 71, XI 224
creber XI 41, XI 224
intercisus XIX 36
scabrosus XI 41
vitreus XI 232
Rhabdonema XX 56
japonicum XX 56
sparsicostatum XX 56, XX 58
Rhabdosphaera XI 230
claviger XI 44, XI 230

clavigera XVI 87
crebra XI 41, XI 224
elliptica XIX 34
gladius XI 45
inflata XV 124
morionum XI 230
recta XI 226
rudis XI 45
scabrosa XI 41
semiformis XI 71, XI 244
spinula XI 226
stylifera XI 182
tenuis XI 42, XI 228
vitrea XI 208, XI 224, XI 230
RHABDOSPHAERACEAE *XI 40, XI 224, XIX 34*
Rhaphoneis XX 56
amphiceros XX 56
elongata XX 56, XX 58
fatula XX 56, XX 58
gemmifera XX 56, XX 58
sachalinensis XX 58
rhetor cf., Lymingtonia XVII 28
rhinoceros, Vasum XV 112
rhinoceros cf., Artostrobium XX 34
Rhinoclavis (Ochetoclava) ocalanum XII 138
Rhinocurus XIV 88
Rhipocephalus XIII 116
RHIZAMMININAE *XIX 92*
Rhizophagites XX 9
Rhizophora mangle XII 107
RHIZOPODEA *XIV 90*
Rhizosolenia XX 58
alata cf. XX 58
americana XX 56
barboi XX 58, XX 60
hebetata XX 58
hiemalis XX 58, XX 60
praebergonii XX 58, XX 60
styliformis XX 58, XX 60
Rhoipites
angustus XVII 29
latus XVII 29
rhombica, Dictyocha XX 86
rhombifolia, Quercus XIII 60
rhombiformis, Diconodenium XII 212, XII 220
RHOMBOHEDRA, *Deflandrea* **XII 195,** *XII 214*
rhomboidalis, Bolivina XI 282
rhomboidalis, Bolivineta XI 282, XI 292
rhomboidalis, Helicopontosphaera XI 212
rhomboidalis, Textularia XI 282
rhombus, Biddulphia XX 43, XX 48
rhombus, Zygoceros XX 43
Rhyncholampas gouldii XVIII 73, XVIII 130
rhynchostoma, Manticoceras XVII 49
Rhytiodentalium XVI 77
kentuckyensis XVI 79
Riberia australiensis XVI 74
richei, Dimya XV 50
richthofeni, Dimyodon XV 51
Ricinula XIX 63
deformis XIX 66
echinata XIX 86
ferruginosa XIX 67
rosea XIX 68
rutila XIX 80
Riddellia
arachnoidea XIII 61
cooperi XIII 61
tagetina XIII 61
riddellii, Selaginella XIII 61
ridellii, Solidago XIII 18
riedeli, Heliolithus XIX 9
rigbyi, Xestoleberis XIV 154, XIV 155
rigida, Cancellaria XII 40
rigida, Isophyllastrea XIII 118
Rimalina XIV 88
ringens, Cardium XVI 6
ringens, Cardium (Bucardium) XVI 14, XVI 18
ringens, Papyridea XIII 164
Ringicardium XVI 8
riosecanus, Xancus XVIII 52
Risomurex XII 104, XIX 66
caribbaeus XIX 77
deformis XIX 66
galbensis XIX 83
gilbertharrisi XIX 78
mosquitensis XIX 66, XIX 70
muricoides XIX 77
roseus XIX 66
rutilus XIX 70
schrammi XIX 66
riveroae, Globigerina XV 10
ROBERTINACEA *XI 300*
Robulina XIV 88
Robulus XIV 88
cocoaensis XIV 85
gutticostatus XIV 85
hoppoensis XIV 94
lacerta XIV 94
midwayensis XVII 35
rosettus cf. XVII 35
senni XIV 94
robusta, Cyclococcolithina XIX 22, XIX 26
robusta cf., Cyclococcolithina XIX 22, XIX 28
robusta, Endictya XX 50, XX 54
robusta, Megacythere XIV 150
robustum, Cardium XIII 185
robustum, Dinocardium XVII 103, XVIII 120, XIX 61
robustum, Laevicardium (Dinocardium) XVI 36
robustum, Lithostromation XI 204
ROBUSTUM, *Trithyrodinuim* **XII 198,** *XII 218, XII 220*
robustus, Coscinodiscus XX 46
robustus, Cyclolithus XIX 26
robustus, Endictya XX 50
roederi, Amphicoryna XVI 94
Rogerella XIX 56
rohri, Cytheridea XIX 150, XIX 152
rohri, Cyprideis XIX 150
rohri, Truncorotaloides XI 11
ROLANDI, *Miliola* **XVIII 8**
rolandii, Nitzschia XX 54, XX 58
rosa, Braarudosphaera XI 188, XI 212
Rosalina XI 286
candeiana XI 286, XI 294, XVI 92

floridana XI 286, XI 294
floridensis XVI 94
orbicularis XI 286
parkinsoniana XI 288
suezensis XVI 94
rosea, Discorbis XI 286
rosea, Engina XIX 68
rosea, Harpa XVI 155, XVIII 56
rosea, Morula XIX 70
rosea, Ocenebra (Risomurex) XIX 70
rosea, Ricinula XIX 68
rosea, Rotalia XI 286
rosefieldensis, Paracypris XII 59
rosettus cf., Robulus XVII 35
roseum, Sistrum XIX 68
roseus, Muricopsis XIX 70
roseus, Risomurex XIX 66
roseus, Muricopsis (Risomurex) XIX 68
rossi, Acrosterigma (Ovicardium) XVI 22
rossi, Trachycardium XVI 8
Rossiella XX 58
praepaleacea XX 54, XX 58
rostrata, Gastrochaena (Spenglaria) XII 161
ROSTROCONCHIA *XVI 61*
Rotalia XI 288
beccarii parkinsoniana XI 288
beccarii tepida XI 290
dubia XI 288
limbata XV 11
menardii XIV 66, XV 11
parkinsoniana XI 288
rosea XI 286
squammosa XI 294
tepida XI 290
ROTALIACEA *XI 288*
Rotaliammina XI 272
mayori XI 272, XI 280
ROTALIIDAE *XI 288*
ROTALIINA *XI 279, XI 300, XIV 90, XIX 190*
ROTALIINAE *XI 288*
Rotalina
dubia XI 288
hirsuta XIV 62
truncatulinoides XIV 66
Rotalipora XI 306
cushmani XI 306
greenhornensis XI 306
rothi, Pontosphaera XI 206
Rothpletzia XVII 51
FLORIDANA XVII 51, *XVII 53*
rudista XVII 51
rothpletzi, Protocardia (Globocardium) XVI 32
Rotularia XVIII 73
vernoni XVIII 73
rotulata, Cristellaria XV 5
rotundata, Globulina XVII 35
rotunda, Triloculina XI 276
rotundum, ?Ctenidodinium XVIII 152
rotunda, Dichadogonyaulax XVIII 152
rotundum, Pemma XI 50, XI 52, XI 56, XI 190, XI 191
rotundus, Lophodolithus XI 26, XI 29
Roussea monilifera XVII 29
Rouxia XX 58
californica XX 58, XX 60
yabei XX 60
ruber, Globigerinoides XIV 23, XIV 46, XIV 52, XV 12, XV 18, XVI 85, XVI 94, XVIII 28
rubescens, Globigerina XIV 19, XIV 36, XVI 85
rubidus, Muricopsis (Risomurex) XIX 68
rubidum, Sistrum XIX 66, XIX 70
rubra, Globigerina XIV 46, XV 12
rudentis, Laevicardium (Vepricardium) XVI 38
Rudicardium XVI 8
rudis, Murex XI 156
rudis, Pododesmus XIX 55
rudis, Rhabdolithes XI 38, XI 45
rudis, Rhabdosphaera XI 45
rudista, Rothpletzia XVII 51
RUFARIPA, *Dimya* **XV 39,** *XV 40*
rugata, Perissocytheridea XII 93, XII 97
rugiferum, Cardium XVI 7
ruginosa, Phractocytheridea XVII 34
rugipunctata, Cythere XII 69, XIV 145
rugipunctata, Cythereis XII 69, XIV 145
rugipunctata, Favella XII 69, XIV 145
rugipunctata gatunensis, Puriana XIX 139
rugipunctata, Puriana XII 69, XII 78, XIV 145, XIV 150, XIX 134
rugipunctata, Trachyleberis XII 69
Rugoglobigerina XI 306
rugosus, Ceratolithus XI 115, XI 120, XVIII 29
Rugotyphis XVII 126
rugulatus, Insulapollenites XVII 30
rupicola, Epitonium XVII 100
rutila, Engina XIX 80
rutila, Morula XIX 77
rutila, Ricinula XIX 80
rutilus, Muricopsis (Risomurex) XIX 68, XIX 80
rutilus, Risomurex XIX 70
Ryenella XIX 165
RZEHAKINIDAE *XI 271*

S

Sabbatia gracilis XIII 61
sablensis, Hemicytherura XII 78, XII 93, XIV 142
sablensis, Paracypris XIV 139, XIV 146
sabulosa, Quinqueloculina XVI 94
sacculifer, Globigerinoides XVI 94
SACELLUM, *Trigonostoma (Ventrilia) XII 40,* **XII 42**
sacculifera, Globigerina XIV 46, XV 12
sachalinensis, Rhaphoneis XX 58
sagena, Cushmanidea XIX 138
saggitula, Frondicularia XVI 94
sagra, Articulina XI 277, XI 288
sagra, Cancris XVI 94
sagra, Polystomella XI 292
Sagrina XI 284
primitiva XI 284
pulchella primitiva XI 284, XI 292
sagrum, Elphidium XI 292, XI 296

sahnii, Cytheretta XII 89
Sahnia subulata XII 61
saipanensis, Discoaster XI 58, XI 61, XI 65, XI 72, XI 200, XI 232
sakuensis, Bathysiphon XIX 93
salebrosa, Cyprideis XIV 140, XIV 146, XIX 138, XIX 146
salebrosa, Helicopontosphaera XI 214
salebrosa cf., Cyprideis XII 70, XII 93
salebrosa, Vitularia XIII 192
Salixipollenites parvus XVII 29
salleana, Hastula XVII 102
salsum, Ammotium XI 271
salsus, Ammobaculites XI 271
salzwedelensia, Gongylis XI 244, XI 246
samarangae, Cardium XVI 7
samarangae, Nemocardium (Keenaea) XVI 34
samodurovi, Apertapetra XI 29, XI 198
samodurovi, Ericsonia XI 198
samodurovi, Reticulofenestra XI 198
sanctipatricii, Limnocythere XIV 156
sandbergi, Cytherura XII 63, XII 74, XIX 139
sandbergi cf., Cytherura XIV 141, XIV 148
sandbergi, Pumilocytheridea XII 60
sandbergi cf., Pumilocytheridea XII 60, XII 70
Sannilyria XIV 107
santidominici, Jaspidella XVI 120
sappaensis, Limnocythere XIX 154
Saracenaria XIV 88, XIX 182
  ampla XVI 92
  latiformis jamaicensis XVI 94
  pravoslavlevia XIV 86
  toddae XIV 94
Saracenella XIV 88
sarasotana, Loxoconcha XII 73
sarasotana sp. cf., Loxoconcha XIV 145, XIV 152
sarasotana, Oculina XVI 100
sarasotaensis, Balanus XVI 99, XVI 100
sarsiae, Coccolithus XI 14, XI 16, XI 22, XI 194, XI 228
sarsi, Cytherelloidea XII 93
Sasarma XVII 114
sauridens, Conus XII 16
saxatalis, Scutellaria XIII 26
saxea, Thoracosphaera XVI 87, XIX 30, XIX 42
saxorum, Miliola XVIII 5, XVIII 6, XVIII 8
saxorum, Miliolites XVIII 5
saxorum, Quinqueloculina XVIII 5
sayana, Oliva XVI 113, XVII 101, XIX 61
scabriculum, Buccinum XII 34
scabriculus, Murex XII 34
scabriusculus, Murex XII 34
scabriextima cf., Siltaria XVII 29
scabrosa, Rhabdosphaera XI 41
scabrosus, Blackites XI 38, XI 41
scabrosus, Rhabdolithus XI 41
scalaformis, Murex XI 127
scalariformis, Murex XI 127
scalarinus, Murex XI 133
scalarioides, Aspella XI 136
scalarioides, Aspella (Aspella) XI 148
scalarioides, Murex XI 127
scalarioides lamellosa, Aspella XI 141
scalarioides obeliscus, Aspella XI 140
scalarioides paupercula, Aspella XI 140
scalaris sp. aff., Spirocyrtis XX 34
scalaroides, Dermomurex (Dermomurex) XI 127, XI 150
scalaroides, Murex XI 133
scalatella, Olssonella XII 36
scalatella, Trigonostoma XII 36
Scaphella junonia XVII 101
Scapholithus fossilis XVI 87
SCAPHOPODA *XVI 56, XVI 61, XVII 104*
schalki, Postligata XVIII 68
schauinslandii, Dictyocha XX 92
Schedocardia XVI 8
scherffelii, Pleurochrysis XI 12
Schizaster
  beckeri XVIII 130
  ocalanus XVIII 130
schizoblata, Dichadogonyaulax XVIII 152
schizoblatum?, Ctenidodinium XVIII 152
schlumbergeri, Sigmoilina XVI 94
schlumbergi, Dimydon XV 51
schmidti, Cardium XVI 41
schmitti, Macrocypris XII 59
schrammi, Anadonta XVI 97
schrammi, Engina XIX 76
schrammi, Muricopsis XIX 66
schrammi, Muricopsis (Risomurex) XIX 68, XIX 76
schrammi, Ocenebra (Risomurex) XIX 66
schrammi, Risomurex XIX 66
schubarti, Potamocypris XIX 148
schubarti sp. aff., Potamocypris XIX 148
schwartzii, Opephora XX 54, XX 58
SCIAENIDAE *XV 103*
scissum,? Ctenidodinium XVIII 152
scissura, Reticulofenestra XI 197
scitula, Globorotalia XIV 31
scitula, Globorotalia (Obandyella) XVIII 28
scitula, Pulvinulina XIV 66
scitula scitula, Globorotalia (Turborotalia) XV 12
SCLERACTINIA *XI 173*
Scobinella XI 88
scolymoides, Turbinella XII 116, XVIII 48, XVIII 50
Sconsia
  hodgei XVI 97
  laevigata XVII 124
  striata XVII 124
  sublaevigata XVII 124
scopula, Turbinella XVIII 50
SCOPULARIA *XVI 138*
scopulus, Xancus XVIII 52
Scortimus XIV 88
scotica, Venus XVI 165
scottae, Neocaudites XIX 139
sculptilis, Phacorhabdotus XVII 34
sculpturatus, Petaloconchus XVI 97
scutaeforme, Perichlamydium XX 14
Scutellaria saxatalis XIII 26
Scuticabolus lapidaris XII 228
secans, Massilina XI 275
secans, Quinqueloculina XI 275, XVIII 10

Seila adamsi XVII 100
Selaginella riddellii XIII 61
sellaeformis, Cubitostrea XV 120
sellaeformis, Ostrea XI 181
sellii, Helicopontosphaera XVI 146, XVIII 29, XVIII 35
sellwoodii, Ctenidodinium XVIII 150
sellwoodii, Dichadogonyaulax XVIII 152
selseyense, Uvigerina XVI 94
Semele
bellastriata XVII 104
proficua XVII 104
SEMELIDAE *XVII 104*
semiaspera, Diplodonta XVII 103
semiasperum, Cardium XVI 7
semiasperum, Nemocardium (Nemocardium) XVI 30, XVI 34
semicircularis, Hulingsina XIX 139
semiformis, Rhabdosphaera XI 71, XI 244
seminae, Denticula XX 48
seminae, Denticulopsis XX 48
SEMINOLENSIS, *Muricopsis (Risomurex)* **XIX 88,** *XIX 89*
seminuda, Odostomia XVII 102
seminula seminula, Sphaeroidinellopsis XVIII 26, XVIII 35
seminula, Sphaeroidinellopsis XIX 130
seminulina, Globigerina XVIII 35
seminulina, Sphaeroidinella XV 12
seminulum, Helicopontosphaera XI 36, XI 39, XI 42, XI 214, XI 234
seminulum, Helicosphaera XI 39, XI 40, XI 212, XI 214
seminulum, Quinqueloculina XI 274, XVIII 10
seminulum, Serpula XI 274
seminulum lophota, Helicopontosphaera XI 40
seminulum lophota, Helicosphaera XI 40, XI 212
Semioculopollis sp. A XVII 36
semiplicata, Anachis XVII 101
semistriata, Fasciolaria XV 113
SENARIUM, *Trigonostoma (Ventrilia) XII 40,* **XII 44**
semitranslucens aff., Cativella XIX 155
senax, Aspella (Aspella) XI 132
senex, Aspella XI 123, XI 132, XI 134
senni, Robulus XIV 94
senonicus, Gleicheniidites XVII 29
senticosum, Laevicardium (Trachycardium) XVI 40
senticosum, Trachycardium (Dallocardia) XVI 28
sentus, Acanthotrophon XII 118, XIV 131
Septastrea sp. XVIII 120
septatus, Spiniferites XVII 37
Septocardia XVI 8, XVI 18
peruviana XVI 16
typica XVI 8, XVI 16
Septemchiton vermiformis XVI 62
Septigerina XVIII 159
Septopora XIX 115
serena, Pseudoplicapollis XVII 39
serga, Kurtziella XVII 102
serpens, Cribrorobulina XIV 83
Serpula seminulum XI 274
serraculoides, Bramletteius XI 9, XI 186
SERRANIDAE *XV 103*
serrata, Atrina XVII 102
serratum, Pemma XI 192, XI 222
serratus, Micrantholithus XI 192
Serripes XVI 8, XVI 22
groenlandicus XVI 36, XVI 38
serrulatum, Cardium XVI 38
setipunctata, Cytheridea XIV 141
setipunctata, Haplocytheridea XIV 140, XIV 146
setosum, Microdinium XII 220, XII 222
SEVERNENSIS, *Deflandrea* **XII 195,** *XII 216*
sexangula, Aspella (Takia) XI 152
sexangula, Eupleura XI 152
sexangula, Murex XI 152
sexangulus, Dermomurex (Viator) XI 152, XI 154
sexiesperforata, Leodia XVIII 141
sexiesperforata, Mellita XIX 53
SEXTONI, *Conus* **XII 31**
shaleri, Endopachys XI 173
shepstonense, Fragum XVI 5
shilohensis, Murexiella XI 148
siberica, Melosira XX 52, XX 56
sibirica, Fordilla XVI 76
sidebottomi, Triloculina XI 276
sidebottomi, Sigmolina XI 276
Siderastrea radians XIII 118
sigaretina, Globularia XI 99
sigillata, Dimya XV 50
sigillina, Dimyodon XV 51
sigillina, Plicatula XV 51
Sigmavirgulina XI 296
tortuosa XI 296, XI 298
sigmoides, Zygodiscus XVII 31, XIX 32, XIX 44
Sigmoilina
schlumbergeri XVI 94
sidebottomi XI 276
Sigmoilopsis flintii XVI 92
Sigmomorphina undulosa XIV 83
silicata, Lyria XIV 110
silicata, Lyria (Lyria) XIV 110, XIV 122
silicatus, Modiolus XIX 171
SILICOFLAGELLATAE *XX 85*
silicorum, Paleotetradinium XII 220
Siltaria
pacata XVII 29
scabriextima cf. XVII 29
SILURIFORMES *XV 102*
similis, Cancellaria XII 34
similis, Cyprideis XIX 145
similis, Dimyodon XV 51
similis interstricta, Dimyodon XV 51
simplex, Anomia XVII 102, XIX 61
simplex, Aulacodiscus XX 42, XX 48
simplex, Cythere XII 60
simplex, Jonesia XII 60
simplex cf., Jonesia XII 60, XII 70
simplex, Lithostromation XI 204, XI 236
simplex, Ptiloncodus XVI 65
simplex, Trochoaster XI 52, XI 55, XI 56, XI 204
simplicissimus, Hemidiscus XX 50, XX 56
Simplicodolium XIX 178

simrothi, Cardium (Trigoniocardium) XIII 180
simrothi, Trigoniocardia XIII 180, XVIII 40
simrothi, Trigoniocardia (Trigoniocardia) XIII 166, XIII 170, XIII 180
simulator, Manticoceras XVII 49
singleyi, Latirus XIII 195
singularis, Ericsonia XI 196
Sinum perspectivum XVII 101
sinuosa, Isophyllia XIII 116
Siphocampe XX 34
arachnea XX 32, XX 34
lineata XX 34
nodosaria XX 32, XX 34
Siphogenerina XI 284
advena XI 282
costata XI 284, XI 292
transversa XV 6
Siphogenerinoides XIX 190
SIPHOGENERINOIDIIDAE *XIX 190*
siphonifera, Globigerina XIV 38, XV 12
siphonifera, Globigerinella XIV 20, XIV 38, XIV 44, XV 12
siphonifera, Hastigerina XVI 94
siphonifera, Hastigerina (Hastigerina) XV 12, XVIII 26
siphonifera siphonifera, Hastigerina (Hastigerina) XV 12, XV 22, XVI 146
Siphonina XI 286
claibornensis XI 6
pulchra XI 286, XVI 94
SIPHONINIDAE *XI 286*
Siphonochelus XVII 128
woodringi XVII 128
Siphonochelus (Pilsbrytyphis) woodringi XVII 126, XVII 128
SIPHONOTESTALES *XX 85*
sirenoides, Prorastomas XIV 161
Sistrum XIX 64
ferruginea XIX 67
ferrugineum rubidum XIX 66
nicocheanum XIX 84
nodulosum XIX 67
roseum XIX 68
rubidum XIX 66, XIX 70
situliformis, Hayella XI 9, XI 186
SKINNERI, *Macrocyprina* **XII 58,** *XII 66*
sloani, Eutrephoceras XII 237, XII 238, XII 240
Smaragdia chipolana XVI 159
smidti, Cardium XVI 41
smirna, Ledina XVII 33
smithi, Spongurus XX 14
smithii, Cancellaria XII 35
smithii, Diplothyra XVII 104
smithii, Venericardia XV 71
smithvillensis, Textularia XI 8
smithvillensis, Spriloculina XVIII 17
snavelyi, Pemma XI 190, XI 192
sol, Stylotrochus XX 14
Solariorbis
infracarinata XVII 100
mooreana XVII 100
Soldania XIV 88
soldanii, Gyroidina XV 6
SOLECURTIDAE *XVII 104*
SOLEIDAE *XV 103*
Solen
bullatus XIII 164
viridis XIX 108
SOLENIDAE *XVII 103*
soleniforme, Cardium XIII 164, XVI 8
soleniforme, Papyridea XIII 164
solereperta, Perna XIX 161
soleniformis, Papyridea XVI 20, XVI 22
solida, Discolithina XI 240
Solidago
ohioensis XIII 18
ridellii XIII 18
solidissima similis, Spisula XVII 103, XIX 61
solidus, Discolithus XI 240
solidus, Holodiscolithus XI 240, XI 242
solitus, Chiasmolithus XI 16, XI 20, XI 193, XI 226
solitus, Coccolithus XI 20, XI 194
sorenseni, Acanthotrophon XIV 132
sorensoni, Acanthotrophon XII 118
SORITACEA XVIII 3
Sorites XI 278, XVIII 3
marginalis XI 278
SORITIDAE *XI 277, XVIII 3*
SORITINAE *XI 278*
soror, Diplodonta XVII 103
soror, Voluta XIV 112
sorrentoensis, Acanthocardia (Agnocardia) XVI 16
sorrentoensis, Cardium XVIII 43
soyeri, Laevicardium XVI 38
sparsicostatum, Rhabdonema XX 56, XX 58
sparsus, Biantholitus XIX 8
SPATANGOIDA *XVIII 130*
Spatangus purpurens XVIII 134
spatiosum, Cardium XVI 7
spatiosum, Plagiocardium (Maoricardium) XVI 18
speciosa, Deflandrea XII 196
speciosa cf., Deflandrea XII 196, XII 216
speciosa, Eucrassatella XIX 61
speciosa, Hauerina XI 277
speciosa, Spriloculina XI 277
speciosum, Cardium XVI 6
spectrum, Chicoreus (Chicoreus) XI 90, XI 92
spectrum, Murex XI 90
spectrum, Murex (Chicoreus) XI 90
speculum, Dictyocha XX 92
speculum, Distephanus XX 92, XX 94
Spengleria [see also Gastrochaena (Spengleria)] XII 161
sphaericus, Cannopilus XX 85, XX 86
Sphaerocardium XVI 8
Sphaerogypsina globosus XVI 94
sphaeroidea, Protocardia (Globocardium) XVI 32
sphaeroideum, Cardium XVI 7
Sphaeroidina
bulloides XVI 92
bulloides dehiscens XIV 52
sphaeroides obliquiloculata, Pullenia XIV 58
Sphaeroidinella XIV 52
dehiscens XIV 25, XIV 52, XIV 60, XVI 94

dehiscens excavata XIV 52
dehiscens subdehiscens XV 12
dehiscens immatura XV 11, XV 22
disjuncta XV 12
seminulina XV 12
Sphaeroidinellopsis
nepenthes constricta XV 11, XVIII 34
seminula XIX 130
seminula seminula XVIII 26, XVIII 35
subdehiscens subdehiscens XV 12, XV 22, XVI 146, XVIII 26, XIX 130
Sphenaster metula XV 13
SPHENOLITHACEAE *XI 54, XI 232, XII 166*
Sphenolithus XI 54, XI 232
abies XI 119, XV 13, XV 28, XVI 146, XVIII 26, XIX 130
furcatolithoides XI 48, XI 54, XI 185
heteromorphus XI 54, XI 236
moriformis XI 48, XI 54, XI 232, XI 244
obtusus XI 55
pacificus XI 54, XI 232
pseudoradians XI 54, XI 236
radians XI 55, XI 56, XI 232, XI 234, XI 244
springeri XI 234
Sphincterules XIV 88
Sphoerocardium XVI 8
spicaeformis, Guttulina XVI 94
spicata, Bulimina XI 284
spicata cf., Bulimina XI 284
spicata, Lagena XVI 94
spillmani, Cardium XVI 8
spillmani, Protocardia (Pachycardium) XVI 30
spinata, Brizalina XVI 94
Spinidinium XII 196
clavum XII 196, XII 218
densispinatum XVII 31
sp. XVII 37
vestitum XVII 37
spinifer, Trionyx XVII 71
Spiniferites XII 189, XVIII 152
cornutus XII 189, XVII 37
cornutus cf. XII 189, XII 208
granosus XII 190
membranaceus XII 190
multibrevis XII 190
ramosus granomembranaceous XVII 37
ramosus granosus XII 190, XII 208
ramosus membranaceus XII 190
ramosus multibrevis XII 190
ramosus ramosus XII 189, XII 208
septatus XVII 37
spp. XVII 30
Spinophenia XVI 82
SPINOSIFRONS, *Agnocardia XVIII 38,* **XVIII 43**
spinossima, Stephanopyxis XX 60
spinosum, Cardium XVI 38
spinosum, Cardium (Cerastroderma, Acanthocardia) XVI 38
spinosum, Cardium (Papyridea) XIII 165
spinosus, Blackites XI 40, XI 202, XI 204, XI 224, XI 226
spinosus, Discolithus XI 226
spinula, Rhabdosphaera XI 226
spinulosa atlantica, Reussella XI 284
spinulus, Blackites XI 226
spiralis, Globorotalia XIX 11
spiralis, Trochita XI 163
spiralis, Zygodiscus XVII 32
spirata, Calyptraea XI 165
spirata, Calyptraea (Trochita) XI 163
spirata, Lagena XVI 94
spiratum plagosum, Busycon XVII 101
spiriferum, Strioterebrum XVIII 62
Spirillina XI 288
denticulata XI 288
limbata denticulata XI 288
vivipara XI 288, XI 296, XVI 94
SPIRILLINACEA *XI 288*
SPIRILLINIDAE *XI 288*
SPIRILLININAE *XI 288*
Spirocyrtis XX 34
scalaris sp. aff. XX 34
subscalaris XX 32, XX 34
Spirolaea vernoni XII 140, XVIII 73
Spirolina XI 278, XIV 83
Spirolina XI 278, XIII 83
acicularis XI 278, XI 290
agglutinans XI 271
arietinus XI 278
Spiroloculina XI 272, XVIII 15
angulata XI 273
antillarum XI 273, XI 282, XVI 92
antillarum angulata XI 273, XI 282
arenata XI 273, XI 282
byramensis XVIII 15
dentata XVI 92
grata XI 273
grata angulata XI 273
imprimata XVIII 16
lamposa XVIII 16
newberryensis XII 141
smithvillensis XVIII 17
speciosa XI 277
SPIROLOCULININAE *XI 273*
Spiroplectammina XVIII 159
Spirulaea XII 143
vernoni XII 141
Spisula solidissima similis XVII 103, XIX 61
splendens, Actinoptychus XX 41
splendens, Pterocorys XX 24
SPONDYLIDAE *XV 35*
spondyliformis, Dimya XV 50
spondylopsis, Plicatula XI 108
Spondylus XIII 186, XV 39, XIX 174
bostrychites XIV 128, XIX 174, XIX 175
calcifer XIX 168
dumosus XII 141
plicatus XI 108
Spongaster pentas XX 8
Spongocore XX 14
puella XX 14
puer XX 14, XX 16
Spongodinium XII 190
delitiense XII 190, XII 208, XVII 30
SPONGODISCIDAE *XX 13*

Spongodiscus
gigas XX 14
osculosus XX 14
Spongopyle XX 14
osculosa XX 14, XX 16
Spongotrochus XX 14
glacialis XX 14, XX 16
venustum XX 14, XX 18
SPONGURIDAE *XX 13*
Spongurus XX 13
smithi XX 14
sp. XX 13, XX 14
SPORTELLIDAE *XVI 160*
springeri, Sphenolithus XI 234
SPUMELLARIA *XX 12*
spurius, Conus XII 22
squammosa, Cymbaloporetta XI 294
squammossa, Rotalia XI 294
Stachys cordata XIII 26
stainforthi, Amphimorphina XVIII 32
Stalagmium XIX 164
stamineus, Calyptraphorus XV 72
staplini, Limnocythere XIX 154
starcki, Dimyella XV 34
staurion, Birkelundia XI 22, XI 195
staurion, Chiasmolithus XI 195
staurion, Coccolithus XI 22, XI 194, XI 195
staurion, Cruciplacolithus XI 22, XI 26, XI 195, XI 238
stauromatos, ?Ctenidodinium XVIII 152
stauromatos, Dichadogonyaulax XVIII 152
staurophora, Micula XVII 32, XIX 44
staurophorus, Discoaster XIX 44
staurophorus, Nannotetraster XIX 44
staurophorus, Trochoaster XIX 44
stavensis, Coccolithus XI 197
stavensis, Intratripollenites XVII 28
STAVENSIS, *Voorthuyseniella XII 150, XII 152,* **XII 155,** *XII 157*
steinhatchee, Brissopsis XVIII 135
stella, Actinoptychus XX 41
stella, Cheilea XI 170
stella, Discoaster XI 65, XI 66
stellaris, Coscinodiscus XX 46
stellaris, Polycladolithus XI 55
stellata, Ceratobulimina (Ceratocancris) XI 181
stellatum, Hystrichosphaeridium XII 185
stellatus, Glyphodiscus XX 50, XX 56
stelligera, Nonionina XI 298
stelligerum, Astrononion XI 298
Stenocypris XIX 148
major XIX 148
sp. XIX 148
STENOGLOSSA *XI 132, XII 105*
Stenoplax conspicua XVI 66
stenostoma, Conus XII 16
stephanense, Vasum XV 113
Stephanodiscus XX 60
sp. XX 60
Stephanogonia XX 60
actinoptychus XX 60
hanzawae XX 60
polyacantha XX 60
Stephanopyxis XX 60
apendiculata XX 60
horridus XX 60
nidulus XX 64
spinossima XX 60
turris XX 60
stephensoni cf., Megacythere XII 93, XII 97
Stereochlamis XVI 138
Stetsonia XI 286
inuta XI 286, XI 294
STEWARTI, *Typhis (Rugotyphis)* **XVII 126**
Stichmaptyx XVI 138
Stichocorys XX 26
delmontensis XX 24
peregrina XX 26
wolffii XX 34
Stichopera XX 26
pectinata XX 26
Stictodiscus XX 60
buryanus XX 60
californicus XX 60, XX 62
stimpsoni, Conus XII 24
stimpsonii, Eupleura XII 110, XVI 46
stintoni, Preophidion XV 100, XV 102
Stomatorbina concentrica XVI 92
storrsi, Dimyodon XV 51
stradneri, Dictyocha XX 92
stradneri, Discoaster XI 61
stradneri, Distephanus XX 92, XX 98
stradneri, Micrantholithus XI 192
stradneri, Pemma XI 50, XI 190, XI 192, XI 222
Stradnerius dictyodus XI 197
straminea, Lithophaga XIX 169
straminius, Lithodomus XIX 169
strattoni, Hanzawaia XI 300
strattoni, Truncatulina XI 300, XVI 94
Strephonella XVI 106
STRIARCINAE *XVIII 71*
striata, Attiliosa XII 111, XII 114, XII 124, XII 126, XIV 132
striata, Lagena XI 279
striata, Lenticulina XIV 94
striata, Megacythere XIV 150
striata, Muricidea XII 111, XIV 131
striata, Oolina XI 279
striata, Sconsia XVII 124
striatoconus, Conosphaeridium XII 18
striatoconus cf., Conosphaeridium XII 181, XII 198
striatula, Bolivina XI 282
striatula, Marginulina XVI 94
STRIATUM, *Trithydrodinium* **XII 197**, *XII 218*
striatus, Acanthotrophon XIV 132
strictus, Momipites XVII 39
strigata, Crepidula XI 166
Strigatella americana XIV 115
Strigilla mirabilis XVII 103, XIX 61
strigosa, Diploria XIII 118, XIII 128
Strioterebrum XVIII 61
ANGELII *XVIII 62,* **XVIII 65**
bowdenensis XVIII 64
brechincastrensis XVIII 65
dislocatum XVIII 61

indocayapum XVIII 61
ischna XVIII 65
meesmanni XVIII 65
protexta XVIII 64
quadrispiralis XVIII 62, XVIII 64
spiriferum XVIII 62
trispiralis XVIII 64
weisbordi XVIII 61, XVIII 62
STROMBIDAE *XVII 101*
Strombus XV 48
alatus XVI 97, XVII 101, XIX 61
gigas XIII 14
proximus XV 110
strongi, Agatrix XII 39
Stylaster XIII 113
sp. XIII 118
Stylatractus
sp. XX 13
universus XX 13
stylifer, Braarudosphaera XI 188, XI 214
stylifera, Rhabdosphaera XI 182
styliformis, Rhizosolenia XX 58, XX 60
Styliolina fissurella XVII 48
Stylochlamydium venustum XX 14
Stylodictya XX 14
camerina XX 16
cornuspira XX 16
heliozoides XX 16
ornata XX 16
validispina XX 14, XX 18
Stylopora XIX 172
Stylosphaera angelina XX 13
Stylotrochus sol XX 14
subalata, Lenticulina XIV 86
subanceps, Aspella XI 125
subanceps, Eupleura XI 126
subanceps, Ranella XI 125
subaenariensis, Bolivina XV 6
subaenariensis mexicana, Bolivina XVI 168
subaenariensis mexicana, Bolivina (Brizalina) XVI 168
subangulata, Gyroidina XVII 35
subarcuata, Dentalina XIV 83
subcarinata, Pullenia XVI 94
subcoronata, Melongena XVI 152
subcrenata, Glycimeris XVIII 68
subcrenata, Glycymeris XVIII 68
subdehiscens subdehiscens, Sphaeroidinellopsis XV 12, XV 22, XVI 146, XVIII 26
subdepressus, Clypeaster XIII 126
subdisticha, Ericsonia XI 196
subdolus, Neopleurodon XVIII 161
subfasciatum, Dolium (Eudolium) XIX 179
subfasciatum, Eudolium XIX 177
subfasciatum, Eudolium (Galeodolium) XIX 178
subfasciatum conica, Eudolium (Galeodolium) XIX 178
subfasciatum crassilabiata, Eudolium (Galeodolium) XIX 178
subfasciatum inflata, Eudolium (Galeodolium) XIX 178
subfasciatum magnovoidea, Eudolium (Galeodolium) XIX 178
subfasciatum oblongata, Eudolium (Galeodolium) XIX 178
subfasciatum pantanensis, Eudolium (Galeodolium) XIX 178
subfasciatum percostata, Eudolium (Galeodolium) XIX 178
subfasciatum subtuberculata, Eudolium (Galeodolium) XIX 178
subfasciatum supratuberculifera, Eudolium (Galeodolium) XIX 178
subfasciatum trilatetuberculata, Eudolium (Galeodolium) XIX 178
subfasciatum tuberculifera, Eudolium (Galeodolium) XIX 178
subfasciatum unituberculifera, Eudolium (Galeodolium) XIX 178
subglobosa, Cassidulina XI 298, XVI 94
subgyrata, Glycymeris XVIII 68
sublaevigata, Sconsia XVII 124
sublodoensis, Discoaster XI 56, XI 65
submoniliformis, Conus XII 25, XII 26
subnodosa, Polystomella XI 290
suborbicularis, Biddulphia XX 43, XX 48
suborbicularis, Milolinella XI 277
suborbularis, Triloculina XI 277
suborbiculata, Bairdia XVII 34
subovata, Paramya XVII 104
subpertusa, Ericsonia XVII 31
subpoeyana, Quinqueloculina XI 275, XI 284
subquadrata, Actinocythereis XII 81
subquadrata, Protocardia (Leptocardia) XVI 30
subquadratum, Cardium XVI 7
subreticulatum, Cytheropteron XII 68
subrotunda, Dimya XV 51
subrotunda, Miliolina XI 276
subrotunda, Vermiculum XI 276
subrugosa, Cythere XIX 155
subrugosa, Perissocytheridea XIX 139, XIX 148, XIX 155
subscalaris, Spirocyrtis XX 32, XX 34
subsinuatus, Cantharus (Pollia) XIX 81
subsphaerica, Biloculina XI 275
subsphaerica, Pyro XI 275, XI 284
substriata, Lagena XVI 94
subtilis, Coscinodiscus XX 46, XX 54
subulata, Sahnia XII 61
suezensis, Rosalina XVI 94
suga, Muricopsis (Risomurex) XIX 74, XIX 82
suga, Ocinebrina XIX 82
suga, Tritonalia XIX 81
suga, Tritonalia (Ocinebrina) XIX 82
Sujkowskiella enigmatica XI 244
sulcata, Melosira XX 52
sulcata, Modiola XIX 161, XIX 166
sulcata, Paralia XX 52
sulcatus, Modiolus XIX 168
sulcatus, Pectunculus XVI 165
sulcatum, Linum XIII 26
sulcifera, Terebra XV 110
sulculus, Conus XII 8, XII 10
sullivani, Cytherelloidea XVII 34
sumatrica, Hemicristellaria XIV 94
superba, Marginulina XIV 94

supplingensis, Interpollis XVII 36
suppressus, Cyclostremiscus XVII 100
suprasulcatus, Potamides XII 14, XVI 159
surculus, Discoaster XI 120, XV 16, XV 28, XVI 146, XVIII 26
sutilis, Murex XV 112
suturalis, Orbulina XIV 50, XIV 56
Svalbardella XII 197
australina XII 197, XII 226
Sveltia [see also Cancellaria (Sveltia)] XII 35
varicosa XII 35
swaini, Cytherura XII 63, XII 74
swiftiana, Corbula XVII 104
symbolica, Ctenocardia (Ctenocardia) XVI 22
symbolica cf., Ctenocardia (Ctenocardia) XVI 24
symbolicum, Fragum XVI 6
symbolophora, Coscinodiscus XX 46, XX 54
symmetricus, Athleta XV 73
Symplocos
contracta XVII 28
gemmata XVII 29
Symplocospollenites XVII 27
sp. aff. XVII 29
Syndendrium diadema XX 43
Synedra XX 62
doliolus XX 56
jouseana XX 62
nitzschioides XX 62
Synthetoceras XVII 72
Syracosphaera
bisecta XI 197
histrica XVI 87
pulchra XI 119
wechesensis XI 34, XI 210
SYRACOSPHARACEAE *XI 236, XIX 42*
syracusana, Pontosphaera XI 30
Syringodium filiforme XI 259
Systematophora XII 204
areolata cf. XII 226
placacantha XII 224, XII 228

T

tabularis, Coscinodiscus XX 46
Tagelus
divisus XVII 104
plebeius XVII 104
tagetina, Riddellia XIII 61
Takia [see Dermomurex (Takia)] XI 130, XI 149
Talityphis XVII 124
talquinensis, Balanus XVI 98
TAMPAE, *Endopachys* **XI 173**, *XI 174*
tampae, Glycymeris XII 143
tampaensis, Lyria XIV 114
tampaensis, Modiolus XIX 171
tani, Discoaster XI 68, XI 199
tani nodifer, Discoaster XI 60, XI 65, XI 66, XI 199
tantulus, Caprifoliipites XVII 29
Tanyosphaeridium XII 228
variecalamum XII 224, XII 228
tanypetalis, Echinolampas XVIII 130
TAPETUS, *Conus* **XII 16**, *XII 18*
TAPPANELLA XVIII 10
jacksonenis XVIII 10, XVIII 12
punctatocostata XVIII 10, XVIII 12
taurinensis, Dermomurex (Viator) XI 158
taurinensis, Murex XI 156
taustoma, Cribrorobulina XIV 83
Tectonatica pusilla XVII 101
Tegula XIX 78
fasciata XI 168
Teichichnus XVIII 106
Teinostoma biscaynense XVII 100
TELEOSTI *XV 102*
tellea, Polystira XI 88
Tellidora cristata XVII 103
Tellina
aequistriata XVII 103, XIX 61
alternata XVII 103
iris XVII 103
listeri XIX 61
texana XVII 103, XIX 108
TELLINIDAE *XVII 103*
Teloceras XVII 72
Tendagurium XVI 8
tenella, Actinocyclus XX 41, XX 44
tenella, Hadriania (Hexachorda) XI 128
tenellum, Ctenidodinium XVIII 150
tenellus, Dermomurex (Dermomurex) XI 128, XI 138
tenellus, Eupodiscus XX 41
tenellus, Globigerinoides XIV 23, XIV 48
tenellus, Murex XI 133
tenellus, Murex (Trophon) XI 149
tenera, Cancellaria XII 42, XII 44
tenerum, Trigonostoma XII 44
tenta, Macoma XVII 103, XIX 108
tenuicostata, Venericardia XVI 41
tenuiforatus, Cruciplacolithus XI 22, XI 28, XI 32
tenuiplicata, Ostrea XV 50
tenuipolus, Momipites XVII 39
tenuis, Blackites XI 38, XI 42, XI 206, XI 224, XI 226, XI 228
tenuis, Bulimina XVI 94
tenuis, Cruciplacolithus XI 20, XVII 31, XIX 24
tenuis var. A, Cruciplacolithus XIX 24, XIX 38
tenuis var. B, Cruciplacolithus XIX 24, XIX 38
tenuis var. C, Cruciplacolithus XIX 26, XIX 38
tenuis, Cyclinella XVII 104
tenuis, Heliorthus XI 195, XIX 24
tenuis, Rhabdolithes XI 44, XI 228
tenuis, Rhabdosphaera XI 42, XI 228
tenuis, Umbellosphaera XVI 87
tenuissima, Bythocythere XII 76
tenuissima, Machaerina XII 76
tenuissima cf., Machaerina XII 76, XII 82
tenuissimoides, Xiphichilus XII 76
tenuisulcatum, Cardium XVI 7
tenuisulcatum, Nemocardium (Habecardium) XVI 34
tepida, Ammonia XI 290, XVI 94
tepida, Rotalia XI 290
Terebra

basteroti XVIII 61
concavata XVII 102
dislocata XVII 102, XIX 61, XIX 109
kugleri XVIII 61
sulcifera XV 110
Terebra (Strioterebrum)
gatunensis kugleri XVIII 61
quadrispiralis XVIII 64
trispiralis XVIII 64
Terebralia dentilabris XVII 159
TEREBRIDAE *XVIII 61*
teres, Eulimastoma XVII 102
TEREBRIDAE *XVII 102*
Tergestiella barnesae XIX 28
terminalis, Nudopollis XVII 39
terquemi, Neoconorbina XVI 94
tertium, Laevicardium XVI 38
tessellata, Nerita XVII 131
tessellata, Quinqueloculina XVIII 5
testudinum, Thalassia XI 256, XIII 116
tetracladia, Periptera XX 56, XX 58
TETRACLADINA *XVI 129*
Tetracolporopollenites
lesquereuxianus XVII 29
longipollinius XVII 29
megadolium XVII 29
Tetralithus XI 179
tetrapera, Cyrtocapsa XX 22
tetrapera, Cyrtocapsella XX 22, XX 24
texana, Asterigerina XI 181
texana, Eosolea XV 100, XV 103
texana, Esolea XV 103
texana, Tellina XVII 103, XIX 108
texasiana, Agriopoma XVII 104
texasiana, Aligena XVII 103
texasianum, Dentalium XVII 104
texasianus, Donax XVII 103
TEXINA XVIII 17
FERAY *XVIII 12*, **XVIII 17**
TEXININAE XVIII 17
textilis, Fasciolaria XVIII 52
textilis, Turbinella XVIII 50
textilis jamaicensis, Turbinella XVIII 48
textilis jamaicensis, Xancus XVIII 52
textilis, Murexiella (Subpterynotus) XII 14
Textularia XI 272, XV 3
agglutinans XI 272, XI 280
floridana XVIII 159
hockleyensis XII 140
mississippiensis XV 6
parvula XI 272, XI 280
rhomboidalis XI 282
smithvillensis XI 8
Textulariella XV 3
TEXTULARIIDAE *XI 272*
TEXTULARIINA *XI 271, XIX 92, XIX 185*
TEXTULARIINAE *XI 272*
TEXTULARINA *XVIII 157*
THAEROCYTHERINAE *XII 69, XIV 145*
THAIDIDAE *XIII 193*
THAIDINAE *XII 134*
Thais XIII 194
haemastoma canaliculata XVII 101
haemastoma floridana XVII 101
Thalassia XVIII 65
testudinum XI 256, XIII 116
Thalassinoides XVIII 108
Thalassionema XX 62
antiqua XX 62
hirosakiensis XX 62
nitzschioides XX 62
Thalassiosira XX 62
antiqua XX 62
aspinosa XX 62
convexa XX 62
decipiens cf. XX 62, XX 64
excentrica XX 62, XX 64
gravida XX 64
fossilis XX 62, XX 64
hyalina XX 62, XX 64
hyalinopsis XX 62, XX 64
miocenica XX 62, XX 64
nativa XX 62, XX 64
nidulus XX 62, XX 64
oestrupii XX 30, XX 62, XX 64
pacifica cf. XX 62, XX 64
praeconvexa XX 62, XX 64
punctata XX 62, XX 64
sp. XX 64, XX 66
zabelinae XX 62; XX 66
Thalassiothrix XX 66
longissima XX 64, XX 66
Thalassiphora pelagica XVII 37
Thalassocypria sp. XIX 139
Thalmanninella XI 306
Theliostyla XVII 132
Theocalyptra XX 26
bicornis XX 26
Theoconus zancleus XX 30
Theocorys XX 26
redondoensis XX 26
redondoenis sp. cf. XX 26
sp. XX 26, XX 28
Theocyrtis redondoensis XX 26
THEOPERIDAE *XX 20*
thetidis, Cardium XVI 8
thetidis, Nemocardium (Pratulum) XVI 30
thielei, Laevicardium (Trachycardium) XVI 38
thiergartii, Nudopollis XVII 39
thomasii, Deflandrea XII 200
thompsoni, Eudolium XIX 177
thompsoniana, Planera XVII 28
Thoracosphaera XIX 42
imperforata cf. XIX 44
MULTIPERFORATA *XIX 30, XIX 32*, **XIX 42**
pelagica XIX 42
saxea XVI 87, XIX 30, XIX 42
spp. XVII 31, XIX 44
THORACOSPHAERACEA XIX 42
thumii, Triceratium XX 64, XX 66
Thyrscocyrtis
bromia XX 34
triacantha XX 34
Tibia XI 96
Tibialectus XIX 168
Ticinella XI 306

tigrina, Dimya XV 46, XV 48
Tilia instructa XVII 28
timmsi, Lithatractus XX 13, XX 14
Timoclea grus XVII 104
Tinophodella ambitacrena XVIII 34
titus, Chiasmolithus XI 18, XI 20, XI 194, XI 226
tjibaliungense, Trigonostoma XII 43
toddae, Biloculinella XVI 94
toddae, Saracenaria XIV 94
togatum, Cirsotrema XVI 155, XVI 156
togatum, Epitonium XVI 155
togatum, Epitonium (Cirsotrema) XVI 155
tollini, Epitonium XVII 100
tomkilenyii, Xestoleberis XIX 156
Tonna galea XVII 101
TONNACEA *XIX 178*
TONNIDAE *XVII 101, XIX 178*
Torcula XII 138
henkeri XII 142
martinensis XII 142
martinensis henkeri XII 142
torquatus, Dolicholatirus XIII 195
TORQUIFER XVI 149
PITTORUM XVI 150
torrida, Pseudonodosaria XI 279
torrida, Rectoglandulina XI 279
tortuosa, Bolivina XI 296
tortuosa, Sigmavirgulina XI 296, XI 298
tortuosus, Ophiraphidites XVI 125
torularius, Murex (Bolinus) XI 153
toulmini, Marginulina XIV 94
Touroconcha lapidiscola XIX 139
Toweius XI 21, XIX 38
craticulus XIX 38
petalosus XIX 28, XIX 38
Toxodon XVII 5
TOXOGLOSSA *XII 3*
TRABECULA, *Regadrella XVI 130,* **XVI** *136*
TRACHYCARDIINAE *XIII 154, XVI 11, XVI 18*
Trachycardium XIII 154. XVI 8, XVII 55, XVIII 37
belcheri XIII 154
elongatum XIII 161
muricatum XVII 103
magnum XIII 161
MOLLYNI XVII 55, *XVII 56*
isocardia XVII 103
parile XIII 150, XIII 156, XIII 178
rossi XVI 8
virile XIII 146, XIII 154, XIII 182
Trachycardium (Agnocardia) acrocome XIII 153
Trachycardium (Conilocardium) XVI 18
cestum XIII 150, XIII 157, XIII 158, XIII 178, XVI 22, XVI 28
Trachycardium (Dallocardia) XVI 18
dominicense XVII 56
quadragenarium XVI 20, XVI 40
Trachycardium (Mexicardia) XVI 18
procerum XVI 20, XVI 28
Trachycardium (Phlogocardia) XVI 18
belcheri XVI 20, XVI 28
Trachycardium (Trachycardium) XVI 18
consors XVI 28
isocardia XVI 20
TRACHYLEBERIDIDAE *XII 81, XIV 152, XIX 155*
TRACHYLEBERIDINAE *XII 81, XIV 152, XIX 155*
Trachyleberis
exanthemata gomillionensis XII 81
gomillionensis XII 81
rugipunctata XII 69
Trachypollia
nodulosa XIX 67
turricula XIX 74, XIX 81
trajectionis, Conus XII 13
transitus, Choanopollenites XVII 36
translucida, Crenella (Modiolaria) XIX 166
transsylvanicus, Dermomurex XI 127
transsylvanicus, Murex XI 129
transversa, Anadara XVII 102, XIX 61, XIX 108
transversa, Siphogenerina XV 6
Transversopontis XI 34, XI 218
exilis XI 218, XI 240
fimbriatus XI 220, XI 242
obliquipons XI 34, XI 38, XI 220, XI 222, XI 240
ocellatus XI 34, XI 36, XI 42
prava XI 222
pulcher XI 35
pulcheroides XI 35, XI 38, XI 222
pulchra XI 35, XI 36, XI 42, XI 222
pulchriporus XI 38, XI 39, XI 42, XI 222
transversum, Papyridea XIII 164
trapezina, Modiola XIX 165
Tremadictyon XVI 138
Tremalithus
eopelagicus XI 13
jugatus XI 12
oamaruensis XI 19, XI 193
Trematodiscus microporus XX 13
Trembolites XVI 142
Tretomphalus XI 286
atlanticus XI 284, XVI 92
Trialatella [see also Dermomurex (Trialatella)] XI 130, XI 144
cunninghamae XI 144
triacantha, Thyrsocyrtis XX 34
triangula, Bachmannocena XX 94
triangula, Dictyocha (Mesocena) XX 94
triangula, Mesocena XX 94, XX 100
triangularis, Actinocythereis XII 81, XIV 152
triangularis, Discoaster XI 66, XI 68, XI 72
triangularis, Lithostromation XI 204
triangularis, Trochoaster XI 204
triangulata, Bairdoppilata XIV 137
triangulata sp. aff., Eucythere XIX 139
Triangulina XVI 82
Triatriopollenites sp. XVII 28
Tribia epomis XII 38
tribrachiatus, Marthasterites XI 11
tribuloides, Eucidaris XIII 114
tricarinata, Clavulina XI 272
tricarinata, Quinqueloculina XI 275
tricarinata, Triloculina XVI 94
Triceratium XX 66
articum XX 64, XX 66
condecorum XX 64, XX 66

elegans XX 64, XX 66
thumii XX 64, XX 66
validum XX 64, XX 66
TRICHECHIDAE *XIV 162*
Trichecus XIV 162
Trichodinium XII 191
hirsutum XII 191, XII 208
Tricolpites
asper XVII 39
sp. XVII 30
Tricolporites sp. XVII 36
TRICORATUS, *Conus* **XII 20**, *XII 22*
tricornatum, Loxocorniculum XIX 139
tricorniculatus, Amaurolithus XVIII 33
tricorniculatus, Ceratolithus XI 118, XI 120
tridens, Biddulphia XX 43, XX 48
tridens, Denticella XX 43
Trifaricardium XVI 8
nomurai XVI 8
Trifarina XI 282, XIX 182
bella XI 284, XI 292, XVI 92
occidentalis XVI 94
Trigona pellucida XII 42, XII 44
Trigonaphera XII 39
bicolor XII 40
WITHROWI XII 39, *XII 40*
Trigonarca XVIII 68, XVIII 71
TRIGONIIDAE *XVII 13*
Trigoniocardia (Americardia) XVI 20
burnsii XIII 181
columba XIII 166, XIII 178
DECIDUA *XIII 166, XIII 174,* **XIII 184**
media XIII 166, XIII 184, XVI 24
Trigoniocardia (Apiocardia) XVI 20
obovale XIII 170, XIII 172
obovalis XVI 22
Trigoniocardia XIII 177, XVI 8
antillarum XIII 177
apateticum XIII 180
caboblanquensis XIII 180
simrothi XIII 180, XVIII 40
Trigoniocardia (Trigoniocardia) XVI 20
burnsii XIII 166, XIII 174, XIII 181
granifera XVI 22, XVI 24
simrothi XIII 166, XIII 170, XIII 180
Trigonopyxidium ginella XVII 37
Trigonostoma XII 42, XII 44
agassizii XII 38
alumensis XII 44
betsiae XII 44
druidi XII 44
ecuadoriana XII 43, XII 44
perspectiva alumensis XII 44
scalatella XII 36
tenerum XII 44
tjibaliungense XII 43
triumpha XII 42
vinnulum XII 39
trigonostoma, Delphinula XII 42, XII 44
Trigonostoma (Ventrilia)
bullatum XII 42
SACELLUM *XII 40,* **XII 42**
SENARIUM *XII 40,* **XII 44**
trigonula, Miliola XI 276
trigonula, Triloculina XI 276, XVI 94
trilineata, Pandora XVII 104, XIX 108
Trillium nivale XIII 18
trilobus, Globigerinoides XVI 94
Triloculina XI 6, XI 275
bassensis XI 275, XI 286
bermudezi XI 275, XI 286
bicarinata XI 275, XVIII 3
carinata XI 275
circularis XI 276
comis XI 276
fichteliana XI 276
fiterrei meningoi XI 275, XI 286
gracilis XI 275
insignis XVI 94
labiosa XI 276
linneiana XI 276
linneiana comis XI 276
meningoi XI 275
mississippiensis XVIII 14
oblonga XI 276
planciana XI 276
rotunda XI 276
sidebottomi XI 276
suborbularis XI 277
tricarinata XVI 94
trigonula XI 276, XVI 94
triloculinoides, Globigerina (Subbotina) XII 237
triloculinoides, Globorotalia XIX 11
trinidadensis, Globorotalia XIX 11
trinidadensis, Krithe XIX 139
trinitatis, Turbinella XVIII 47
trinitatis, Xancus XVIII 52
trinodiferus, Calytraphorus XV 72
Trionyx
farox XVII 71
spinifer XVII 71
tripartita, Deflandrea XII 191
Triphora perversa nigrocincta XVII 100
TRIPHORIDAE *XVII 100*
triplistriata, Cythereis XIV 154
triplistriata, Neocaudites XIV 154
triplistriata sp. cf., Neocaudites XIV 152, XIV 154
Triplofusus XIII 195, XV 113
Tripodiscus concentricus XX 42
tripterus, Pterynotus XVI 52
trispiralis, Strioterebrum XVIII 64
trispiralis, Terebra (Strioterebrum) XVIII 64
TRISSOCYCLIDAE *XX 20*
Trithyrodinium XII 197
evittii XII 197
fragile XII 197
ROBUSTUM XII 198, *XII 218, XII 220*
STRIATUM XII 197, *XII 218*
Triton XI 97
cantrainei XI 138, XII 45
Tritonalia
caribbaea XIX 70, XIX 77
fusiformis XIX 81
quilonica XI 129
suga XIX 81
turrita XII 105

Tritonalia (Ocinebrina)
caribbaea XIX 77
fusiformis XIX 81
fusiformis suga XIX 82
suga XIX 82
tritus, Liliacidites XVII 28
triumpha, Trigonostoma XII 42
triumphis, Cocconeis XX 43, XX 50
trivittatus, Nassarius XIX 108
Trochammina XI 272
conglobata XVII 20
sp. XI 272
TROCHAMMINIDAE *XI 272*
TROCHAMMININAE *XI 272*
trochiformis, Calyptraea XI 163
trochiformis, Calyptraea (Trochita) XI 163, XI 164
trochiformis, Patella XI 164
trochiformis, Trochita XI 164
trochiformis, Turbo XI 163
trochilia, Cancellaria XII 35
Trochita [see also Calyptraea (Trochita)] XI 163
radians XI 165
spiralis XI 163
trochiformis XI 163
Trochoaster XI 55
duplex XI 55, XI 204
operosus XI 202
radiatus XI 56, XI 58
simplex XI 52, XI 55, XI 56, XI 204
staurophorus XIX 44
triangularis XI 204
Trochoasterites hohnensis XI 69
TROCHOS, *Blackites XI 210*, **XI 230**
Trochus
conchyliophorus XI 164
radians XI 164
troelli, Bregmaceros XV 100, XV 102
trojanus, Cassidulus XVIII 138
Trophon (Aspella) engonatus XI 136
Trophon XII 104, XII 118
geversianus XII 118
TROPHONINAE *XIV 131*
Trophonopsis XIV 131
Tropicardium XVI 8
Tropidocardium XVI 8
troyensis, Fordilla XVI 76
Trudopollis plena XVII 38
truncata, Barnea XVII 104
truncata, Cytherelloidea XVII 34
TRUNCATA, DIVERISPINA XII 184, *XII 200*
truncata, Xestoleberis XVII 34
Truncatulina
americana strattoni XI 300
floridana XI 294
humilis XVIII 35
strattoni XI 300
truncatulinoides, Globorotalia XI 80, XIV 32, XIV 66, XIV 76, XVI 85, XVI 94
truncatulinoides, Rotalina XIV 66
Truncorotaloides rohri XI 11
Truncorotataloides (Acarinina) mckennai XII 237
Truncorotataloides (Morozovella)
aequa XII 237
angulata XII 237
apanthesma XII 237
Truncorotataloides (Planorotalites) pseudomenardii XII 237
tschoppi, Paracytheridea XII 69, XIV 143, XIV 148, XIX 139
tsugarvensis, Actinocyclus XX 41, XX 44
tuberculata, Acanthocardia (Rudicardium) XVI 18
tuberculata, Cushmanidea XII 62
tuberculata, Hulingsina XII 62, XII 70
tuberculata, Quinqueloculina XVIII 6, XVIII 12
tuberculata, Turbinella XVIII 48
tuberculata, Vitularia XIII 194
tuberculatum, Cardium XVI 8
tuberculatum, Vasum XV 110, XV 112
tuberculatus, Chiton XVI 70
tuberculatus, Xancus XVIII 52
tuberculifera, Cytherella XII 92
Tuberculodolium XIX 178
tuberosus, Ophiraphidites XVI 129
tubifer, Typhis XVII 124
tubifera, Discosphaera XI 182
tubiferum, Hystrichosphaeridium XII 188, XII 206, XVII 37
Tubucellaria nodifera XII 141
TUBULOGENERININAE *XIX 190*
Tucetona XVIII 67
tulensis, Muricopsis XIX 86
tulipa, Fasciolaria XV 113
tulipus, Modiolus XIX 171
Tulongocardium XVI 8
tumescens, Discoaster XI 58, XI 62, XI 68
tumida, Globorotalia XIV 33, XIV 68, XIV 76, XVI 85, XVI 94
tumida flexuosa, Pulvinulina XIV 62
tumidosa, Cytherella XII 92, XVII 34
tumidulus, Neoeponides XVI 94
tumidum, Cardium XVI 40
TUMULOSIMILIS, *Cytheropteron* **XII 68**, *XII 78*
TUNICULA, *Fragum XIII 166, XIII 170*, **XIII 172**
tuomeyi, Athleta XV 73
turbinea, Braarudosphaera XIX 22, XIX 40
Turbinella XVIII 51
angulata XVIII 48, XVIII 50
bronni XIII 196
chipolana XVIII 50
colinensis XVIII 47
dalli XVIII 50
falconensis XVIII 47
grata XVIII 50
HERMANI *XVIII 48*, **XVIII 51**
hoerlei XVIII 48, XVIII 50
laevigata XVIII 47
magdalensis XVIII 50
perexilis XIII 195
praelaevigata XVIII 52
praeovoidea XVIII 47
regina XVIII 47
scolymoides XII 116, XVIII 48, XVIII 50

scopula XVIII 50
textilis XVIII 50
textilis jamaicensis XVIII 48
trinitatis XVIII 47
tuberculata XVIII 48
valida XV 110, XVIII 47
TURBINELLINAE *XI 277, XVIII 51*
Turbinellus validus XVIII 52
Turbinolia maclurii XI 173
turbinopsis, Conus XII 28
Turbo XVI 159, XIX 78
canaliculatus XI 168
haraldi XI 168
trochiformis XI 163
Turbonilla XIX 57
interrupta XVII 102
Turborotalia [see also Globorotalia (Turborotalia)]
inflata XVI 84, XVI 94
Turborotalita humilis XVIII 26, XVIII 35
turgidula, Cytherella XII 92
turgidus, Interporopollenites XVII 39
turneri, Caribosiren XIV 161
turricula, Cantharus (Pollia) XIX 81
turricula, Trachypollia XIX 74, XIX 81
TURRIDAE *XVII 102*
turriformis, Bifarina XI 8
TURRILINIDAE *XI 280*
turris, Cresswellia XX 60
turris, Stephanopyxis XX 60
turriseiffeli, Clinorhabdus XIX 34
turriseiffeli, Eiffellithus XIX 34
turriseiffeli, Zygolithus XIX 34
turriseiffeli, Zygrhablithus XIX 34
turrita, Tritonalia XII 105
Turritella XVII 17
acropora XIX 61
alabamensis XIX 2
indenta martinensis XII 137
martinensis XII 138, XII 139
Tutcheria XVI 8
tympaniformis, Fasciculithus XIX 8
TYPHINAE *XV 105, XVII 123*
Typhis XVII 124
alatus XVII 124
arcuatus XVII 128
avenatus XVII 128
cleryi XVII 128
expansus XVII 124
francesae XVII 124
gabbi XVII 128
keenae XVII 128
obesus XV 112, XVII 125
perchardei XVII 124
precursor XVII 125
puertoricensis XVII 124
tubifer XVII 124
wenzelidesi XI 96
Typhis (Pilsbrytyphis) gabbi XVII 128
Typhis (Rugotyphis) **STEWARTI XVII 126**
Typhis (Talityphis)
alatus XVII 124, XVII 126
alatus obesus XVII 125
eucteanus XVII 125, XVII 126
obesus XVII 125, XVII 126
sp. XVII 125
typica, Septocardia XVI 8, XVI 16
Tytthodiscus XX 9

U

Uca XVII 114
uchidai, Clinocardium XVI 38
Udotea XIII 116
Umbilicosphaera
cricota XV 13
formosa XI 24
mirabilis XI 119, XV 14, XV 28, XVI 87, XVIII 26
Ulmipollenites
krempii XVII 39
undulosus XVII 29
ulocyma, Chione XVI 97
Umbellosphaera tenuis XVI 87
umbilica, Apertapetra XI 29, XI 198
umbilica, Reticulofenestra XI 26, XI 29, XI 197, XI 228
umbilicus, Coccolithus XI 29, XI 198
umbonata, Cytherelloidea XIX 139
umbonata sp. cf., Cytherelloidea XIX 139
Uncimenia neapolitana XVI 65
uncinata, Calyptraea XI 171
uncinata, Cheilea XI 168, XI 171
uncinata, Globorotalia XIX 11
undata, Glycymeris XIX 61
undulata, Astarte XVI 165
undulatus, Actinoptychus XX 41, XX 46
undulosa, Sigmomorphina XIV 83
undulosus, Ulmipollenites XVII 29
ungulata, Globorotalia XI 302, XIV 33, XIV 68, XIV 78, XVI 85, XVI 94
UNGULINIDAE *XVII 103*
Unio XIX 160
unispinum, Hystrichokolpoma XII 187, XII 204
universa, Orbulina XIV 24, XIV 50, XIV 56, XV 12, XV 22, XVI 94, XVI 146, XVIII 26
universus, Stylatractus XX 13
Urnula quadrupla XVIII 157
Urosalpinx XII 118
floridana XII 105, XII 133
mexicanus XII 133
usitatus, Plicapollis XVII 36
uva, Drupa XIX 64
Uvigerina XI 284, XIX 182
aubergina laevis XI 284
bellula XI 284, XI 292, XVI 92
hispida XVIII 32
laevis XI 284
selseyense XVI 94
UVIGERINIDAE *XI 284*
uvula, Globigerina XV 13
uvula, Globigerinita XIV 27, XIV 56, XIV 62, XV 12, XV 16, XVIII 28

uvula, Pylodexia XIV 56, XV 12

V

Vacuopollis munitus XVII 36
vadosa, Pontosphaera XI 30, XI 208
Vaginulina XIV 85, XIX 182
awaensis XIV 94
gracilis XVII 35
longiforma XVII 35
VAGINULINOPSINAE *XIV 85*
Vaginulinopsis XIV 88
baggi XIV 94
planata XVI 94
spp. XVI 94
valens, Oliva (Omogymna) XVI 116
valida, Turbinella XV 110, XVIII 47
validispina, Stylodictya XX 14, XX 18
validum, Triceratium XX 64, XX 66
validus, Turbinellus XVIII 52
Valvulina XI 272
oviedoiana XI 272
Valvulinaria
mexicana XVI 94
sp. XVII 35
VALVULININAE *XI 272*
VANDENBOLDI, *Actinocythereis* **XII 81**, *XII 86*
vandenboldi, Paracythereidea XIV 142
vandenboldi sp. cf., Paracytheridea XIV 142, XIV 150
vanderstoki, Nummulites XII 141, XVIII 73
vaningeni, Gemmula XVII 123
vanwessemi, Paracytheridea XIV 143
varensalense, Heraultipegma XVI 75
variabilis, Discoaster XI 120, XV 16, XV 28, XVIII 32
variabilis, Matthevia XVI 67, XVI 68, XVI 69
variabilis roemeri, Donax XVII 103
varians, Aspella XI 140, XII 45
Varicardium XVI 8
varicosa, Sveltia XII 35
variecalamum, Tanyosphaeridium XII 224, XII 228
varigatus, Lytechinus XIII 122
varium, Diastoma XVII 100
varricosa, Voluta XII 35
VASIDAE *XIII 196, XV 105*
Vasum
aedificatum XV 112
aldridgei XII 124
aquitanicum XV 113
dominicense XV 110, XV 113
gurabicum XV 112
haitense XV 112
muricatum XIII 122
pugnans XV 113
pugnus XV 110, XV 113
rhinoceros XV 112
stephanense XV 113
tuberculatum XV 110, XV 112
Vasticardium XIII 160, XVI 8, XVI 18
elongatum XIII 162, XVI 20, XVI 36
orbita XVI 38
vaughani, Cristellaria XIV 94, XV 5
vaughani, Dermomurex (Viator) XI 153, XI 158
vaughani, Falsilyria XIV 124, XIV 128
vaughani, Fibularia XVIII 130
vaughani, Lyria XIV 128
vaughani, Murex XI 153
vaughani, Murex (Bolinus) XI 153
vaughani, Murex (Murex) XI 153
vaughani, Orionina XIX 139
vaughni, Orionina XIV 145
veatchi, Hexaplex XI 154
vegai, Lyria XIV 113
VEGRANDIS, *Conus* **XII 18**, *XII 22*
velascoensis, Globorotalia XIX 11
velatus, Calyptraphorus XV 72
velatus compressus, Calyptraphorus XV 72
velatus nodovelatus, Calyptraphorus XV 72
velero, Poirieria (Panamurex) XII 103
Venericardia XV 71, XVI 41
alticostata XI 181
apodensata XV 71
aposmithii XV 71
claiboplata XV 71
constantii XVI 41
cottaldina XVI 41
densata XV 71
dubia XVI 41
dupiniana XVI 41
neocomiensis XVI 41
quadrata XVI 41
smithii XV 71
tenuicostata XVI 41
VENERIDAE *XVII 104, XVIII 123*
venezuelana, Globigerina XV 13
venezuelana, Globoquadrina XIV 9, XV 13, XV 20, XVIII 26
ventosa, Pseudolaesopollis XVII 29
ventricosa, Meoma XVIII 141
ventricosum, Cardium XIII 185
Ventrilia [see also Trigonostoma (Ventrilia)] XII 42, XII 44
ventrilia XII 42, XII 44
ventrilia, Ventrilia XII 42, XII 44
ventriosa, Deflandrea XII 195
Venus
lapicida XII 47, XII 163
danmoniensis XVI 165
ducatelli XIX 171
scotica XVI 165
venustum, Perichlamydium XX 14
venustum, Spongotrochus XX 14, XX 18
venustum, Stylochlamydium XX 14
venustus venustus, Balanus XVI 104
Vepricardium XVI 8
pulchricostatum XVI 8, XVI 14, XVI 16
Vepricardium (Hedecardium) XVI 18
asiaticum XVI 38
waitakiense XVI 18
Vepricardium (Perucardia) XVI 18

brueggeni XVI 16
Vepricardium (Vepricardium) XVI 18
vera, Alnus XVII 29
Vermicularia woodringi XVI 97
vermiformis, Septemchiton XVI 62
Vermiculum
oblongum XI 276
laeve XI 279
subrotunda XI 276
VERMILIONENSIS, *Cytherella XII 90,* **XII 92,** *XIX 138*
vermontensis, Polyatriopollenites XVII 29
vernandi, Actiniscus XI 199
vernoni, Spirolaea XII 140
vernoni, Rotularia XVIII 73
vernoni, Spirulaea XII 141, XVIII 73
Verrutricolporites spp. XVII 29
versa, Discolithina XI 32, XIX 20, XIX 40
versa, Discolithus XIX 40
versa, Pontosphaera XI 31, XI 32, XI 36, XIX 40
versicolor, Dyopteris XIII 61
versus, Discolithus XI 31
Vertebralina
cassis XI 273
mucronata XI 277
Veryhachium hyalodermum XVII 37
vesca, Discolithina XI 208, XI 238
vesicularis, Gryphaea XII 236
vesper, Micrantholithus XI 190
vespertilio, Pyrgo XVI 94
vestitum, Spinidinium XVII 37
Vetericardia XVI 42
Vetericardiella XVI 42
Vetocardia XVI 41
vetustissimus, Coscinodiscus XX 46, XX 54
vetustus, Conger XV 100, XV 102
Viator [see Dermomurex (Viator)] XI 130, XI 150
vibex, Nassarius XVII 101
vicksburgensis, Bitulogenerina XII 143
vicksburgensis, Krithe XII 61
vicksburgensis, Pseudopsammocythere XIX 139
victrix sp. aff., Bairdoppilata XIX 138
vidau, Oliva XVI 107
vieta, Cyclopsiella XII 212, XII 220
viginitiforata, Discolithina XI 208
viginitiforatus, Discolithus XI 206, XIX 40
vineyardensis, Actinocythereis XIX 138
vinnulum, Trigonostoma XII 39
virginiae, Pteropurpura XI 154
virginea, Neritina XVII 100
virginianum, Cardium XVI 8
virginianum, Clinocardium (Planicardium) XVI 38
virginica, Crassostrea XVII 103, XVII 112, XIX 61
Virgulina
compressa XI 296
gunteri XIII 140
mexicana XI 296
miocenica XIII 140
nahoelensis cf. XVII 35
pertusa XIII 140
pontoni XI 296
Virgulinella XIII 140
fragilis XIII 141
lunata XIII 140
pertusa XIII 140
sp. XIII 141
viridis, Solen XIX 108
virile, Cardium (Trachycardium) XIII 154
virile, Trachycardium XIII 146, XIII 154, XIII 182
vistaensis, Muricopsis XIX 65
VITEUS, *Conus* **XII 25,** *XII 26*
vitrea, Rhabdosphaera XI 208, XI 224, XI 230
vitreus, Rhabdolithus XI 232
VITRINELLIDAE *XVII 100*
vittatus, Liliacidites XVII 29
Vitularia XIII 192
crenifer XIII 192
DOMINICANA *XIII 193,* **XIII 194**
equadorana XIII 193
linguabison XIII 192
linguabovis XIII 192
miliaris XIII 192
salebrosa XIII 192
tuberculata XIII 194
vivipara, Spirillina XI 288, XI 296, XVI 94
vivus, Extremipollis XVII 36
VOKESAE, *Hemicytherura* **XIV 142,** *XIV 148*
VOKESAE, HAYNESPONGIA *XVI 134,* **XVI 140**
vokesae, Pterotyphis XI 96
VOKESI, *Basslerites XII 78,* **XII 89,** *XIV 155*
VOKESI, ACHROCHORDIELLA XVI 130, *XVI 133, XVI 138*
vokesorum, Neritopsis XI 104, XI 168
VOKESORUM, *Oliva (Oliva?) XVI 110,* **XVI 112**
Volema XVI 149
myristica XVI 149
paradisiaca XVI 149
Volsella XIX 171
Voluta
angulata XVIII 51
anna XIV 113
barnesii XIV 114
barnsii XIV 114
cancellata XII 34
costata XIV 13
demarcoi XIV 127
guttata XIV 120
harpa XIV 114
ispidula XVI 107
jaspidea XVI 119
musicina XIV 124
nucleus XIV 107
oliva XVI 107
porphyria XVI 107
pulchella XIV 112
reticulata XII 33
soror XIV 112
sp. XV 120
varricosa XII 35
zebra XIV 110
Voluta (Lyria) zebra XIV 114
voluta, Ephedra XVII 39

VOLUTACEA *XII 33, XVI 107, XVIII 51, XVIII 56*
Volutalithes lyroidea XIV 108
VOLUTIDAE *XII 7, XII 33, XIV 107, XV 118, XVII 101*
VOLUTINAE *XIV 120*
Volutocristata XV 118
chiapasensis XV 118
lajollaensis XV 124
Volutospira (Pejona) lajollaensis XV 124
Volvarina
DISCORS XI 308
inepta XI 308
Volvulella persimilis XVII 102
Voorthuyseniella XII 152, XII 157, XIII 135, XVI 81, XVII 117
alabamensis XII 146, XII 148, XII 150, XII 152, XII 157
BAILEYI XVI 87, *XVI 88, XVII 118*
borneensis XII 158, XIII 138
cornudensis XII 155
cornudensis cruciformis XII 155, XIII 138
cruciformis XII 155
dingdenensis XII 158
GREIGI XVI 88, *XVII 117*
irregularis XII 145, XII 157
lageniforme XII 145
lageniformis XII 145, XII 158
maxima XII 158
occidentalis XII 145, XII 157
sp. XII 157, XII 158, XIII 136, XVI 87, XVI 88
sp. α XVII 117, XVII 118
sp. β XVII 118
STAVENSIS *XII 150, XII 152,* **XII 155,** *XII 157*
WILLIAMSAE XVI 88, *XVI 90, XVI 92*
VOSSI, *Admetula XII 36,* **XII 39**
vulgaris, Actinoptychus XX 41
vulva, Cardium XVI 40

W

wadei, Cytheridea (Haplocytheridea) XIV 140
wadei, Haplocytheridea XIV 140
waitakiense, Cardium XVI 7
waitakiense, Vepricardium (Hedecardium) XVI 18
Walcottella XVI 138
walshi, Parvigenerina XI 272
walshi, Pseudobolivina XI 272, XI 280
waltonensis anodosus, Conus XII 26
waltonensis, Conus XII 26
waltoniana **CALHOUNENSIS,** *Oliva (Oliva)* **XVI 108,** *XVI 110*
waltoniana, Oliva (Oliva) XVI 107, XVI 110
wardensis, Cytherura XII 64, XIV 141, XIX 139
warneri, Cytheromorpha XIX 139
washingtonensis, Acanthocythereis XVII 34
waylandi, Cardium (Trachycardium) XIII 164
weberi, Eulimastoma XVII 102
wechesensis, Discolithina XI 210, XI 242
wechesensis, Koczyia XI 32, XI 34, XI 36, XI 210
wechesensis, Syracosphaera XI 34, XI 210
weidenmayeri, Neomonopleura XVII 51
Weisbordella XII 143, XVIII 73, XVIII 137
absicata XVIII 130
caribbeana XVIII 130
cubae XVIII 130
johnsoni XVIII 130
WEISBORDI, *Strioterebrum* **XVIII 61,** *XVIII 62*
wellsi, Pinnocaris XVI 79
wenzelidesi, Typhis XI 96
westi, Oridorsalis XVI 94
westonensis, Dimya XV 51
westralium, Dinogymnium XII 181, XII 198
westralium, Gymnodinium XII 181
wetherbyi, Oligopygus XVIII 128, XVIII 131
Wetzeliella XII 202
pilata cf. XII 202, XII 220
wetzelii, Gonyaulacysta XII 186, XII 202, XII 204
wetzelii, Gonyaulax XII 186
whitei, Cardium XVI 6
whitei, Granocardium (Ethmocardium) XVI 14
whitfieldi, Panopea XVIII 165
Wiesneriella XI 273
auriculata XI 273, XI 282
wilberti, Loxoconcha XII 73, XIX 139
wilcoxiana, Lyria XIV 108
wilcoxiana, Lyria (Lyria) XIV 108, XIV 120
wilcoxoni, Helicopontosphaera XI 216, XI 234
willcoxiana, Lyria XIV 108
williami, Microcardium XVI 40
WILLIAMSAE, *Voorthuyseniella* **XVI 88,** *XVI 90, XVI 92*
WILLIAMSI, *Olssonella* **XII 36,** *XII 40*
williamsoniana, Bulimina XI 280
williamsoniana, Buliminoides XI 280, XI 292
williamsonii, Glyphodesmus XX 50, XX 54
williamsonii, Himantidium XX 50
WITHROWI, *Muricopsis (Risomurex) XIX 72,* **XIX 78**
WITHROWI, *Trigonaphera* **XII 39,** *XII 40*
woehrmanni, Dimyodon XV 51
wöhrmanni, Dimyodon XV 51
wolffii, Stichocorys XX 34
woodii, Nucinela XVIII 162
woodii, Pleurodon XVIII 162
woodringi, Bathyropyramis XX 20, XX 22
woodringi, Discoaster XI 66, XI 68
woodringi, Siphonochelus XVII 128
woodringi, Siphonochelus (Pilsbrytyphis) XVII 126, XVII 128
woodringi, Vermicularia XVI 97
wordeni, Glycymeris XVIII 68
Wythella XII 143, XVIII 73
eldridgei XII 141, XVIII 132

X

XANCIDAE *XVI 150*
Xancus

colinensis XVIII 52
falconensis XVIII 52
gratus XVIII 52
magdalensis XVIII 52
praeovoideus XVIII 52
proavoideus XVIII 52
riosecanus XVIII 52
scopulus XVIII 52
textilis jamaicensis XVIII 52
trinitatis XVIII 52
Xanthidium ramosum XII 189
Xanthiopyxis XX 66
lacera XX 48
oblonga XX 64, XX 66
ovalis XX 64, XX 66.
sp. XX 64, XX 66
Xenikoon XII 228
australis XII 224, XII 228
XESTOLEBERIDIDAE *XIV 155, XIX 156*
Xestoleberis XIV 155, XIX 156
BERMUDEZI *XIX 152,* **XIX 156**
chilensis XIX 156
rigbyi XIV 154, XIV 155
spp. XIX 139
tomkilenyii XIX 156
truncata XVII 34
XESTOS, *Chicoreus (Chicoreus)* **XI 86,** *XI 88*
Xiphichilus tenuissimodes XII 76
Xiphodictua amphixiphos XX 16
Xiphospira XX 16
circularis XX 16
circularis sp. cf. XX 16, XX 18
zilchi, Pelocypris XIX 154
zonata, Engina XIX 64
Zorrita XVII 138
Zygoceros rhombus XX 43
ZYGODISCACEAE *XI 70, XIX 30*
Zygodiscus XIX 32
adamas XIX 32
plectopons XIX 9
sigmoides XVII 31, XIX 32, XIX 44
spiralis XVII 32
ZYGOLITHACEAE *XI 236*
Zygolithus XI 236
aureus XI 242
bijugatus XI 71
chiastus XIX 30
concinnus XIX 30
dubius XI 70, XI 234, XI 236
minutus XI 70, XI 238
obliquipons XI 220
pediculatus XI 238
protenus XIX 32
turriseiffeli XIX 34
Zygosphaera aurea XI 242
ZYGOSPHAERACEAE *XI 71, XI 238*
Zygrhablithus XI 71, XI 244
bijugatus XI 45, XI 66, XI 71, XI 72, XI 244, XI 246
crassus XI 244
intercisus XIX 36
turriseiffeli XIX 34

Y

yabei, Rouxia XX 60
yaguatensis, Lenticulina XIV 94
Yagudinella XVI 8
Yochelcionella XVI 72
cyrano XVI 72
daleki XVI 72
ostentata XVI 72
Yokoyamaina XVI 8
hayamii XVI 8
Yoldia limatula XIX 108
yorktownensis, Cytheropteron XIX 139

Z

zabelinae, Thalassiosira XX 62, XX 66
zancleus, Theoconus XX 30
zapoteca, Admetula XII 39
zebra, Lyria XIV 114
zebra, Voluta XIV 110
zebra, Voluta (Lyria) XIV 114
zelandicus, Murex XII 102
zeteki, Muricopsis XIX 86

AKERS, W.H.
XI 119, XV 1, XVI 145, XVIII 21, XX 3, XX 11
ANDERSEN, B.L.
XI 253
ANDERSEN, H.V.
XVIII 1
BAILEY, J.R.
[See HAMAN and BAILEY]
BAILEY, R.H.
XII 235
BENSON, D.G., JR.
XII 169, XVIII 145
BOLD, W.A. VAN DEN
XIX 141
BYBELL, L.M. [See also FREDERIKSEN, *et al.*]
XI 179
BULLOCK, R.C.
XII 133
BUKRY, D.
[See GARTNER and BUKRY]
CHRISTOPHER, R.A.
[See FREDERIKSEN, *et al.]*
CROFT, M., and G. D. SHAAK
XVIII 127
CRONE, A.J.
[See FREDERIKSEN, *et al.*]
D'ATTILIO, A.,
[See RADWIN and D'ATTILIO; VOKES and D'ATTILIO]
DREZ, P.E.
XVI 105
EDWARDS, L.E.,
[See FREDERIKSEN, *et al.*]
FINGER, K.L.
XVI 168, XX 8
FLOWERS, G.C.
[See ISPHORDING and FLOWERS]
FORD, C.J.
XX 9
FREDERIKSEN, N.O., L.M. BYBELL, R.A. CHRISTOPHER, A.J. CRONE, L.E. EDWARDS, T.G. GIBSON, J.E. HAZEL, J.E. REPETSKI, D.P. RUSS, C.C. SMITH, and L.W. WARD
XVII 23
FREY, R.W., and J.D. HOWARD
XIX 51
GARTNER, S., and D. BUKRY
XI 115
GIBSON, T.G.
[See FREDERIKSEN, *et al.*]
GIBSON-SMITH, W.
[See GIBSON-SMITH and GIBSON-SMITH]
GIBSON-SMITH, J. and W. GIBSON-SMITH
XVII 57, XVIII 61
GIVENS, C.R.
XV 117
GREIG, D.J.
XVII 121
HAMAN, D.
XI 306, XIII 135, XIII 140, XIV 81, XIV 103, XVI 81, XVII 46, XVIII 20, XVIII 159, XVIII 160
HAMAN, D., and J.R. BAILEY
XVII 117
HAMAN, D., and R.W. HUDDLESTON
XVIII 20
HAMAN, D., and B. KOHL
XII 145, XII 157, XIX 181
HAMAN, D., and R.E. MAROLT
XVIII 157
HARRIS, C.W.
[See MILLER, *et al.*]
HAZEL, J.E.
[See FREDERIKESEN, *et al.*]
HOERLE, R.C.
XI 103, XI 176
HOERLE, S.E. [See also PETIT and HOERLE]
XII 1, XII 31
HOERLE, S.E., and E.H. VOKES
XIV 105
HOGANSON, J.W.
[See NICOL, *et al.*]
HOUART, R.
[See VOKES and HOUART]
HOWARD, J.D.
[See FREY and HOWARD]
HUDDLESTON, R.W.
[See HAMAN and HUDDLESTON]
ISPHORDING, W.C., and G.C. FLOWERS
XVII 59
JOHNSON, H.M.
XI 114
JONES, D.S.
[See NICOL and JONES]
KEEN, A.M.
XVI 1, XVI 41
KOCURKO, M.J.
XIII 111
KOHL, B.
[See HAMAN and KOHL]
KONTROVITZ, M.
XII 49, XIV 135
KRANCER, A.
XII 166
LEITCH, L.S.C.
[See MILLER and LEITCH]
MACHAIN-CASTILLO, M.L.
XIX 123
MAROLT, R.E. [See also HAMAN and MAROLT]
XX 85
MARTIN, L.D.
[See WHETSTONE and MARTIN]
MILLER, W., III [See also WHITCOMB and MILLER]
VII 85, XVII 105, XVIII 93, XVIII 123, XIX 91, XIX 97
MILLER, W., III, and L.S.C. LEITCH
XVIII 89

MILLER, W., III, F. WEBB, JR., and C.W. HARRIS
XVII 47
NAVARRETTE, R.M.
XX 39
NICOL, D. [See also SHAAK and NICOL]
XVIII 70
NICOL, D., and D.S. JONES
XVIII 67, XVIII 73
NICOL, D., G.D. SHAAK, and J.W. HOGANSON
XII 137
PALMER, K.V.W.
XV 69
PATTERSON, R.T.
XIX 185, XIX 188
PETIT, R.E.
XII 33
PETIT, R.E., and S.E. HOERLE
XII 44
PETIT, R.E., and D. WILSON
XIX 95
PITT, W.
XVI 155
POJETA, J., JR.
XVI 55
RADWIN, G.E., and A. D'ATTILIO
XIV 131
REIMERS, D.
XIX 1
REPETSKI, J.E.
[See FREDERIKSEN, *et al.*]
RIESS, K.
XIII 1
RIGBY, J.K.
XVI 123
ROTH, B.
XI 308, XVI 149
RUSS, D. P.
[See FREDERIKSEN, *et al.*]
SCHIEBOUT, J.A.
XV 75
SHAAK, G.D.
[See NICOL, *et al.;* CROFT and SHAAK]
SHAAK, G.D., and D. NICOL
XI 105
SHERWOOD, R.W.
XI 1
SKINNER, H.C.
XI 80, XI 176, XI 307, XI 308, XII 32, XII 100, XII 132, XII 165, XII 168, XII 233, XII 234, XII 243, XIII 142, XIII 189, XIV 80, XIV 160, XIV 164, XV 32, XV 53, XV 55, XV 68, XV 116, XVI 122, XVI 153, XVI 154, XVI 167, XVII 50, XVII 116, XVII 120, XVII 130, XVII 134, XVII 138, XVIII 45, XVIII 46, XVIII 60, XVIII 66, XVIII 75, XVIII 88, XVIII 92, XVIII 126, XVIII 143, XVIII 144, XVIII 155, XVIII 156, XVIII 168, XIX 50, XIX 94, XIX 96, XIX 122, XIX 139, XIX 176, XIX 180
SMITH, C.C.
[See FREDERIKSEN, *et al.*]
SNYDER, S.W.
XI 302, XIV 1
STRINGER, G.L.
XV 95
SRIVASTAVA, S.K.
XX 9
VOKES, E.H. [See also HOERLE and VOKES; VOKES and VOKES]
XI 85, XI 96, XI 99, XI 121, XI 163, XII 45, XII 101, XIII 192, XIII 195, XV 105, XVI 54, XVII 123, XVII 131, XVIII 47, XVIII 53, XIX 177
VOKES, E.H., and A. D'ATTILIO
XVI 45
VOKES, E.H., and R. HOUART
XIX 63, XIX 88
VOKES, H.E.
XI 101, XII 47, XII 161, XII 163, XIII 143, XIII 190, XV 33, XVI 157, XVI 165, XVII 51, XVII 55, XVII 135, XVIII 37, XVIII 161, XVIII 163, XVIII 165, XIX 159, XIX 174
VOKES, H.E., and E.H. VOKES
XVII 1
VOORHIES, M.R.
XI 109
WARD, L.W.
[See FREDERIKSEN, *et al.*]
WEBB, F., JR.
[See MILLER, *et al.*]
WEISBORD, N.E.
XVI 97
WELLS, J.W.
XI 173
WHETSTONE, K., and L.D. MARTIN
XIV 161
WHITCOMB, N.J., and W. MILLER, III
XVIII 77
WILSON, D.
[See PETIT and WILSON]

TULANE STUDIES IN GEOLOGY

VOLUME 1, Complete with title page and contents $7.00

VOLUME 2, Complete with title page and contents $7.00

VOLUME 3, Complete with title page and contents $10.00

VOLUME 4, Complete with title page and contents $10.00

VOLUME 5, Complete with title page and contents $10.00

VOLUME 6, Complete with title page and contents $10.00

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

VOLUME 7, Complete with title page and contents $12.00

VOLUME 8, Complete with title page and contents $12.00

VOLUME 9, Complete with title page and contents $12.00

VOLUME 10, Complete with title page and contents $15.00

VOLUME 11, Complete with title page and contents $15.00

VOLUME 12, Complete with title page and contents $15.00

VOLUME 13, Complete with title page and contents $15.00

VOLUME 14, Complete with title page and contents $18.00

VOLUME 15, Complete with title page and contents $18.00

VOLUME 16, Complete with title page and contents $18.00

VOLUME 17, Complete with title page and contents $20.00

VOLUME 18, Complete with title page and contents $20.00

(see earlier issues for individual listing)

Vol. 19, Nos. 1, 2. THE CALCAREOUS NANNOPLANKTON OF THE MIDWAY GROUP (PALEOCENE) OF ALABAMA, by David Reimers; TAPHONOMIC CHARACTERISTICS OF OFFSHORE MOLLUSK SHELLS, SAPELO ISLAND, GEORGIA, by Robert W. Frey and James D. Howard; AN EVALUATION OF THE TAXA *MURICOPSIS* AND *RISOMUREX* (GASTROPODA:MURICIDAE), WITH ONE NEW SPECIES OF *RISOMUREX* and A NEW SPECIES OF *MURICOPSIS (RISOMUREX)* FROM WEST AFRICA, by Emily H. Vokes and Roland Houart; NEW SPECIES OF *BATHYSIPHON* (FORAMINIFERIDA:TEXTULARIINA) FROM FRANCISCAN FLYSCH DEPOSITS, NORTHERNMOST CALIFORNIA, by William Miller, III; PUBLICATION DATES OF HEILPRIN'S EXPLORATIONS ON THE WEST COAST OF FLORIDA, by Richard E. Petit and Druid Wilson, pp. 1-96 (July 31, 1986)– BOUND TOGETHER. $12.00

Vol. 19, Nos. 3, 4. COMMUNITY REPLACEMENT IN ESTUARINE PLEISTOCENE DEPOSITS OF EASTERN NORTH CAROLINA, by William Miller, III; OSTRACODE BIOSTRATIGRAPHY AND PALEOECOLOGY OF THE PLIOCENE OF THE ISTHMIAN SALT BASIN, VERACRUZ, MEXICO, by Maria L. Machain-Castillo; FRESH AND BRACKISH WATER OSTRACODA FROM THE NEOGENE OF NORTHERN VENEZUELA, by W. A. van den Bold; MYTILIDAE (MOLLUSCA:BIVALVIA) FROM THE CHIPOLA FORMATION, LOWER MIOCENE, FLORIDA and AN UNUSUAL DISTORTED *SPONDYLUS* FROM THE MOIN FORMATION (PLEISTOCENE), COSTA RICA, by Harold E. Vokes; NOTES ON THE FAUNA OF THE CHIPOLA FORMATION-XXX: ON THE PRESENCE OF *EUDOLIUM (GALEODOLIUM) SUBFASCIATUM* SACCO (GASTROPODA:TONNIDAE), by Emily H. Vokes; EARLY PLIOCENE *MONTFORTELLA* (FORAMINIFERIDA) FROM ECUADOR, by Drew Haman and Barry Kohl; *KARRERIELLA OBTURACULOIDES*, A NEW AGGLUTINATED BENTHIC FORAMINIFERAL SPECIES and *AMPLECTODUCTINA*, A NEW FORAMINIFERAL GENUS, IN THE SIPHOGENERINODIDAE, by R. Timothy Patterson; pp. 97-191 (December 15, 1986) – BOUND TOGETHER $12.00

VOLUME 19, Complete with title page and contents $20.00

Vol. 20, Nos. 1-3. LATE MIOCENE AND EARLY PLIOCENE SILICEOUS MICROFOSSILS FROM THE UPPER MONTEREY AND LOWER SISQUOC FORMATIONS, SWEENY ROAD, SANTA BARBARA COUNTY, CALIFORNIA, by W. H. Akers, R. E. Marolt, and R. J. Navarette; pp. 1-112 (September 16, 1987) – BOUND TOGETHER. $15.00

VOLUME 20, complete with title page and contents $20.00

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 21

1988

HUBERT C. SKINNER

and

EMILY H. VOKES

Editors

TULANE UNIVERSITY OF LOUISIANA
New Orleans

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY is devoted primarily to the geology and paleontology of the coasts and adjacent land areas of the Gulf of Mexico and the Caribbean Sea. Each number contains an individual monographic study, or several minor studies. As volumes are completed, title pages and tables of contents will be distributed to subscribers and institutions exchanging the entire series.

Manuscripts submitted for publication are evaluated by the editors and for longer papers by an editorial committee selected from the field of the author(s). Contributors need not be members of the Tulane University faculty.

Manuscripts should be submitted on good paper, as original typewritten copy, double-spaced and carefully corrected. Two carbon copies in addition to the original will help expedite editing and assure more rapid publication.

The cost of excessive illustrations and tabular matter may be charged to the author, and will be computed on the cost above that of a normal 10-point page of text.

An abstract not exceeding three percent of the length of the original article must accompany each manuscript submitted. This will be transmitted to any abstracting journal specified by the writer.

Separate numbers or volumes may be purchased by individuals. Subscriptions are not accepted from institutions publishing comparable series; exchange agreements are invited. Authors may obtain copies for personal use at cost.

Address all communications concerning manuscripts and editorial matters, subscriptions, and orders for individual numbers to the editor. Address exchange inquiries to the exchange director.

When citing this series, authors are requested to use the following abbreviations: *Tulane Stud. Geol. Paleont.*

Price for this volume, **$20.00**

* * *

Hubert C. Skinner, *Editor*
Emily H. Vokes, *Editor*
and *Exchange Director*
Tulane Studies in Geology and Paleontology
Earth Sciences Department
Tulane University
New Orleans, Louisiana 70118
U.S.A.

CONTENTS

VOLUME 21

Number		Page
1.	MURICIDAE (MOLLUSCA:GASTROPODA) OF THE ESMERALDAS BEDS, NORTHWESTERN ECUADOR Emily H. Vokes	1
	PLIOCENE EPITONIIDAE OF THE ESMERALDAS BEDS, NORTHWESTERN ECUADOR (MOLLUSCA:GASTROPODA) Helen DuShane	51
2.	AGE AND STRATIGRAPHIC CORRELATION OF THE RAYSOR FORMATION, LATE PLIOCENE, SOUTH CAROLINA Lauck W. Ward and Paul F. Huddleston	59
	OLIGOHALINE FOSSILS FROM THE PLEISTOCENE FLANNER BEACH FORMATION, NORTH CAROLINA William Miller III	77
	GIANT AGGLUTINATED FORAMINIFERIDS FROM FRANCISCAN TURBIDITES AT REDWOOD CREEK, NORTHWESTERN CALIFORNIA, WITH THE DESCRIPTION OF A NEW SPECIES OF *BATHYSIPHON* William Miller III	81
3.	GEOLOGY AND VERTEBRATE PALEONTOLOGY OF A LOWER PERMIAN DEPOSIT ON THE BRAZOS RIVER, BAYLOR COUNTY, TEXAS, WITH THE DESCRIPTION OF A NEW GENUS AND SPECIES OF ACANTHODIAN FISH Walter W. Dalquest, M. John Kocurko, and John A. Grimes	85
	NOTES ON FOSSIL OCTOCORALS AND COMPARISONS OF SOME MODERN AND ANCIENT OCTOCORALS REMAINS M. John Kocurko	105
	SOME MARINE PELECYPOD FAMILIES AND GENERA THAT ARE RELICTS OR LIVING FOSSILS David Nicol	117
	FURTHER NOTES ON *EUDOLIUM (GALEODOLIUM) SUBFASCIATUM* J. Gibson-Smith and W. Gibson-Smith	119
4.	GULF COAST PITTED MILIOLACEA AND RELATED SPECIES IN GRIGNON AND DAMERY, FRANCE Harold V. Andersen	121
	OSTRACODA OF ALACRAN REEF, CAMPECHE SHELF, MEXICO W. A. van den Bold	143

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 21, Numbers 1,2 July 20, 1988

Number 1

MURICIDAE (MOLLUSCA: GASTROPODA) OF THE ESMERALDAS BEDS, NORTHWESTERN ECUADOR
EMILY H. VOKES p. 1

PLIOCENE EPITONIIDAE OF THE ESMERALDAS BEDS NORTHWESTERN ECUADOR (MOLLUSCA: GASTROPODA)
HELEN DUSHANE p. 51

Number 2

AGE AND STRATIGRAPHIC CORRELATION OF THE RAYSOR FORMATION, LATE PLIOCENE, SOUTH CAROLINA
LAUCK W. WARD
and
PAUL F. HUDDLESTUN p. 59

OLIGOHALINE FOSSILS FROM THE PLEISTOCENE FLANNER BEACH FORMATION, NORTH CAROLINA p. 77

and

GIANT AGGLUTINATED FORAMINIFERIDS FROM FRANCISCAN TURBIDITES AT REDWOOD CREEK, NORTHWESTERN CALIFORNIA, WITH THE DESCRIPTION OF A NEW SPECIES OF *BATHYSIPHON*
WILLIAM MILLER, III p. 81

SMITHSONIAN
AUG 0 4 1988
LIBRARIES

TULANE UNIVERSITY OF LOUISIANA
New Orleans

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY is devoted primarily to the geology and paleontology of the coasts and adjacent land areas of the Gulf of Mexico and the Caribbean Sea. Each number contains an individual monographic study, or several minor studies. As volumes are completed, title pages and tables of contents will be distributed to subscribers and institutions exchanging the entire series.

Manuscripts submitted for publication are evaluated by the editors and for longer papers by an editorial committee selected from the field of the author(s). Contributors need not be members of the Tulane University faculty.

Manuscripts should be submitted on good paper, as original typewritten copy, double-spaced and carefully corrected. Two carbon copies in addition to the original will help expedite editing and assure more rapid publication.

The cost of excessive illustrations and tabular matter may be charged to the author, and will be computed on the cost above that of a normal 10-point page of text.

An abstract not exceeding three percent of the length of the original article must accompany each manuscript submitted. This will be transmitted to any abstracting journal specified by the writer.

Separate numbers or volumes may be purchased by individuals. Subscriptions are not accepted from institutions publishing comparable series; exchange agreements are invited. Authors may obtain copies for personal use at cost.

Address all communications concerning manuscripts and editorial matters, subscriptions, and orders for individual numbers to the editor. Address exchange inquiries to the exchange director.

When citing this series, authors are requested to use the following abbreviations: *Tulane Stud. Geol. Paleont.*

Price for this number, $12.00

Hubert C. Skinner, *Editor*
Emily H. Vokes, *Editor*
and *Exchange Director*
Tulane Studies in Geology and Paleontology
Department of Geology
Tulane University
New Orleans, Louisiana 70118
U.S.A.

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 21, Number 1 July 20, 1988

MURICIDAE (MOLLUSCA: GASTROPODA) OF THE ESMERALDAS BEDS, NORTHWESTERN ECUADOR

EMILY H. VOKES
TULANE UNIVERSITY

SMITHSONIAN
AUG 0 4 1988
LIBRARIES

CONTENTS

Page
I. ABSTRACT 1
II. INTRODUCTION 1
III. ACKNOWLEDGMENTS 12
IV. SYSTEMATIC PALEONTOLOGY 13
V. LOCALITY DATA 46
VI. LITERATURE CITED 48

ILLUSTRATIONS

PLATE 1 15
PLATE 2 19
PLATE 3 23
PLATE 4 27
PLATE 5 31
PLATE 6 35
TABLE 1 9

I. ABSTRACT

Inasmuch as the Bolivar Trough, or Atrato Strait, of Colombia and Ecuador is probably the largest and most long-lasting trans-American Tertiary seaway, a study of the muricid gastropods of the Pliocene Esmeraldas beds of Ecuador was undertaken to compare relationships with the contemporaneous Caribbean fauna. The results show much less correlation with the Caribbean fauna than anticipated; only seven of the 21 species studied occur in the Pliocene of the western Atlantic. The greatest number in common with any fauna proves to be 11 that are still living on the coast of western America. But, of these, six no longer occur in Ecuador (one is confined to the Galápagos, one to California, two are found only in the Gulf of California, and two do not extend south of Panama). Of the 21 species treated systematically, three are new: *Murexsul pitti* and *Ceratostoma notiale*, both confined to the Esmeraldas beds; and *Murex (Haustellum) ruthae*, from the Esmeraldas beds and the Recent fauna of the Gulf of California.

In terms of presumed ancestry, 12 of the species have unmistakable Caribbean ancestors, and an additional three are worldwide Tethyan genera that may have come from the Caribbean. However, three are northern California-Japanese in relationship, two probably came directly from West Africa, and one seems to be endemic to the tropical eastern Pacific.

II. INTRODUCTION

It is generally agreed that the opening between the eastern Pacific Ocean and the Caribbean Sea was closed by Late Pliocene time, about 3.3 million years ago. Saito (1976) suggested closure by 3.5 m.a. (latest Early Pliocene; late planktic

EDITORIAL COMMITTEE FOR THIS PAPER
C. ROGER BRISTOW, British Geological Survey, Exeter, England
WILLIAM K. EMERSON, American Museum of Natural History, New York, New York
JUDITH TERRY SMITH, Palo Alto, California

foraminiferal zone N.19) on the basis of foraminiferal differences in the two regions. Keigwin (1978) argued, on the basis of foraminiferal biostratigraphy, that it might be as late as 3.1 m.a. (N.20). This writer (Vokes, 1966, p. 68) once suggested that the faunal differences seen between the mid-Pliocene (N.20)* Pinecrest beds** and the Late Pliocene Caloosahatchee Formation in southern Florida are a reflection of temperature changes brought about by the creation of the Gulf Stream as a result of this closure and, thus, would serve to date the time of closing.

The reasons for accepting times of closure ranging from 5.7 m.a. to 1.8 m.a. have been summarized by Jones and Hasson (1985, pp. 343-348) and they conclude that 3.5 m.a. is still the most likely date for restriction of migration "of most or all microfauna." The data based on other phyla is less precise, for a variety of reasons, but "total emergence of the entire isthmus probably did not occur until sometime after 3.0 m.a., in the latest Pliocene or earliest Pleistocene" (*ibid.*, p. 349).

It is also generally conceded that much of the marine molluscan fauna of the Tropical East Pacific is directly derived from the Caribbean Tertiary fauna. Woodring (1966) did an extensive study of the interchanges and, although his age assignments tend to be a little too old in the current chronology (his Middle Miocene is Pliocene; his Pliocene is Pleistocene), the comparisons are still valid. As he predicted, we have since discovered some of his "paciphiles" (*i. e.*, taxa that are extinct in the Caribbean but still living in the eastern Pacific) in the Recent fauna of the western Atlantic; but the relatively high number of paciphiles remains impressive. In the Muricidae, for example, there are at least six paciphile groups: *Homalocantha, Purpurellus, Ceratostoma, Pterorytis, Bizetiella,* and *Vitularia.*

Given that the longest lasting and probably largest sea connection between the Caribbean and the eastern Pacific was the Bolivar Trough, or Atrato Strait, in western Colombia and Ecuador, an investigation of the late Tertiary Mollusca of the area at the Pacific end of the strait should be expected to reveal a fauna nearly identical to that of correlative faunas in the Caribbean.

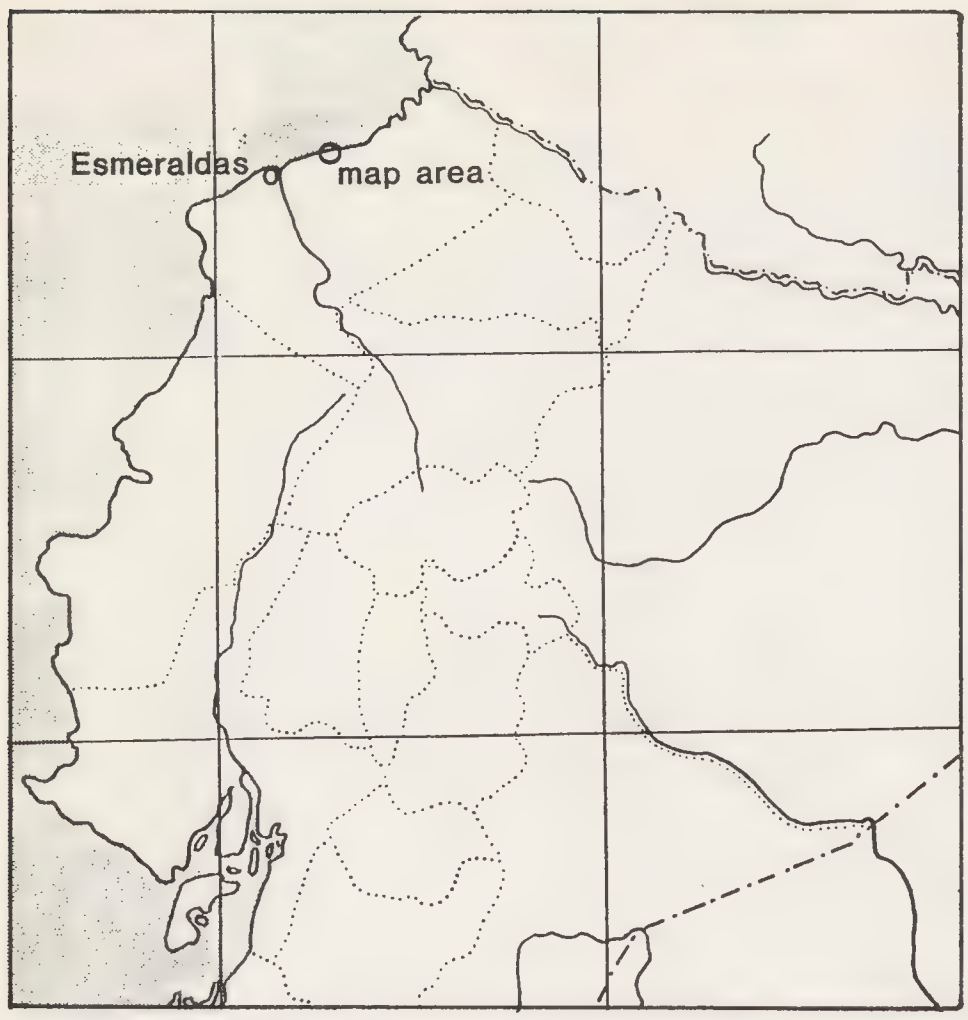
Although outcrops with well-preserved fossil mollusks are rare on the Pacific Coast, along the northwestern coast of Ecuador (text-fig. 1) there is a remarkable occurrence of a series of gravity-flows (here termed the Esmeraldas beds) that bring shallow-water mollusks into the Early Pliocene deep-water clays of the Onzole Formation. Therefore, a study of the Esmeraldas fauna, in particular the members of the family Muricidae, was undertaken to compare the Pacific terminus of the strait with the much better known Caribbean faunas.

The Mio-Pliocene beds along the coast of northwestern Ecuador consist of deep-water, blue-gray silty-shales, with many pelagic foraminifera and sparse megafossils, primarily *Dentalium* shells. However, locally, at Punta Gorda (text-fig. 2), just west of Esmeraldas, and along Rio Camarones, about 10 km east of Esmeraldas, there are interlayered gravity-flow

---

*Technically there is no "Middle" Pliocene; the era is divided into Early and Late. But the planktic zone N.20 lies athwart the boundary (see Berggren, 1973, fig. 1). Therefore, to distinguish between the unequivocal N.19-zoned beds of the Esmeraldas area and others, the informal term mid-Pliocene will here be used for beds that are placed in Zone N.20.

**Petuch (1986, p. 392) pointed out that the name Pinecrest Formation has been used previously for a Triassic unit in Utah (see Wilmarth, 1937, p. 1662). Although the North American Stratigraphic Code (Art. 7c) states "Priority in publication is to be respected, but priority alone does not justify displacing a well-established name by one neither well-known nor commonly used," he proposed to replace it with the name Buckingham Formation (there is also a previous Buckingham Gneiss, from the Pre-Cambrian of Quebec; see Wilmarth, 1937, p. 284). The Buckingham and the Tamiami Limestone, proposed at the same time, are facies of each other, with the Tamiami being the indurated limestone of which the Buckingham is the non-indurated phase. Both carry a fauna of predominately pectens, oysters, barnacles, and echinoderms and presumably represent a more offshore facies than the sandy Pinecrest. Until a definitive study of the southern Florida stratigraphy resolves the nomenclatural problem, the name "Pinecrest beds" will continue to be used to refer to the sandy, highly fossiliferous mid-Pliocene beds of southern Florida.

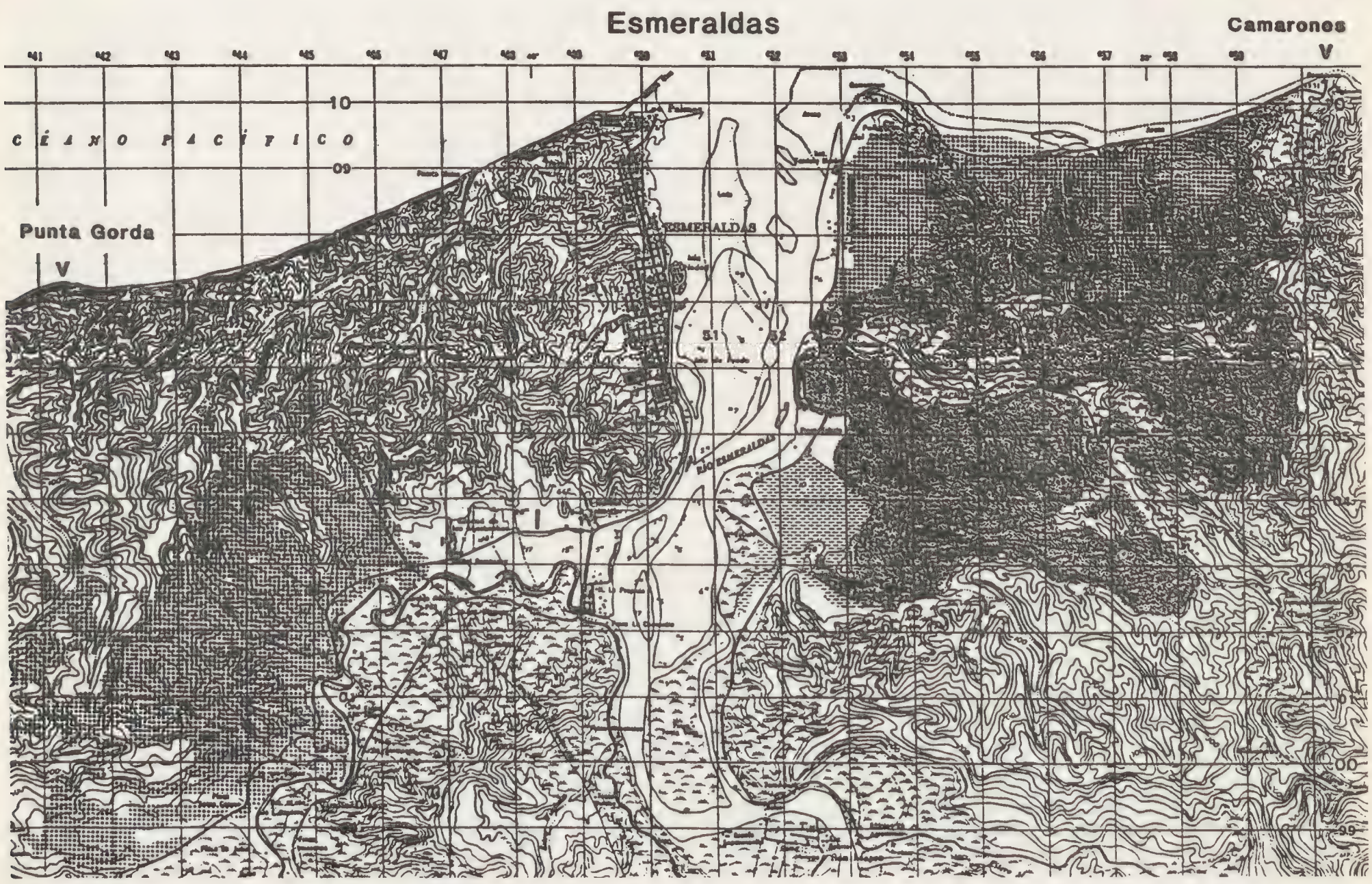


Text-figure 1. Map of northwestern Ecuador, showing study area.

lenses that are virtually coquinas of benthic forams and mollusks in a coarse sand matrix.

The only detailed study of the Esmeraldas mollusk fauna is that by Olsson (1964), who recognized the gravity-flow nature of the fossiliferous lens at Punta Gorda, stating: "The rubble lens is considered to be merely the terminal end of a large rock or mud flow produced by a major landslide which moved glacier-fashion across the shore into the sea, plowing up the bottom and gathering debris as it moved out into deeper water. Thus the littoral shells gathered in shallow water are battered and worn while the deeper water ones are generally in perfect shape" (1964, p. 14).

The name "Esmeraldas Formation" was proposed by Olsson (1942a, p. 260) for the "highly foraminiferal, tuffaceous shales so extensively exposed along the coast of Esmeraldas and along the Esmeraldas river itself." In the Second Edition of the *Lexique Stratigraphique* (1977) Bristow and Hoffstetter admit the name "Esmeraldas Formation" of Olsson, 1942, but state that "Olsson thought that the Esmeraldas Facies was equivalent to the Borbón Formation, differing only by the depositional zone. But in reality the Esmeraldas For-



Text-figure 2. Map of Esmeraldas area, Ecuador.

mation is the Onzole Formation" (1977, p. 142, *translated*). These authors consider the Onzole Formation to include beds from Middle Miocene through Pliocene (N.13 to N.19) in age, with a thickness stated to range up to 550 m. The Esmeraldas beds, which are at the top of the section, have been dated as N. 18-19 (Haman and Kohl, 1986, p.181) on the basis of calcareous nannofossils, or 3.6 to 3.2 m.a. on planktic foraminifera (Rosenberg, 1984, p. 84).

The present writer finds it hard to accept the name Onzole Formation for the beds at Esmeraldas, as they clearly represent a distinct lithologic change from the underlying hundreds of meters of deep-water clays; however, this is the terminology adopted by the Ecuadorian Geological Survey and is being used on all current geological maps.* Therefore, for the purposes of this paper, the term "Esmeraldas beds" will be used for the mollusk-rich shallow-water gravity-flows in northwestern Ecuador located at the top of the Onzole Formation. This is essentially the view adopted in a recent work by Hasson and Fischer (1986), who treat what they call the "Miocene Borbón Formation," and the "Pliocene Esmeraldas Formation." They note (1986, p. 32): "The Borbón Formation [*i.e.*, Onzole Formation] consists mainly of porous, tuffaceous, coccolith-rich diatomites and diatomacous mudstones. It lacks the macrofauna so characteristic of the Esmeraldas Formation."

We were originally apprised of the molluscan localities in the vicinity of Camarones by William Pitt, of Sacramento, California, who visited the site in 1980 and sent the muricids he collected to the writer for examination. His description of the area sounded so fascinating that in January, 1982, we made a visit of about one week to Esmeraldas. Just preceeding this time extensive roadwork had been undertaken by the Ecuadorian government to construct a new road along the coast from Esmeraldas to Punta Verde and ultimately to La Tole, at the mouth of the Rio Santiago. At the time we did not fully appreciate the new outcrops created by this work, until a second trip made with Mr. and Mrs. Pitt, in May, 1986, when we discovered all of the previous localities were completely overgrown.

This unfortunate circumstance nevertheless had a good effect, for not being able to collect at the previous sites, we were able to spend more time exploring other places. In particular, we walked for about 3 kms along the periphery of Punta Gorda (text-fig. 3), searching for Olsson's locality; but it is gone. As Bristow and Hoffstetter have reported (1977, p. 257), it was a localized lens that has been completely eroded away by the sea. But the exposures at low tide along Punta Gorda are amazing. There are a few scattered megafossils, but the main "traces of former life" comprise a spectacular array of ichnofossils (text-figs. 4-6). Olsson observed that "molluscan fossils are sparingly scattered through the formation exposed in the shore platform opposite Punta Gorda, all species having deep-water characteristics . . . A small deep-water *Nassarius* of the *Profundinassa* group is common and often in nestlike aggregates" (text-fig. 7) and "amongst other invertebrate fossils is a simple coral *Flabellum* . . . [of] the *F. japonicum* group [text-fig. 8], a late Tertiary to Recent group of species living in waters ranging from 80 to 1750 fathoms depth" (*ibid.*, p. 13).

Our principal collecting area for shallow-water mollusks is near Camarones (text-fig. 9), a small coastal village about 10 km east of Esmeraldas, or about 20 km by the new paved road. The best locality is the cut-bank of the Rio Camarones, just east of the village (TU 1397, text-figs. 10, 11) – the Quebrada Camarones of Olsson (1964), where large blocks with mollusks fall down from above. But the road-cuts along the highway were excellent during the 1982 construction period, and that at the mouth of the Quebrada (TU 1398, text-figs. 12, 13) showed the sedimentary structures of the gravity-flows especially well. The cliffs to the west of town along the road (TU 1399), also very good in 1982, were almost completely overgrown by 1986.

Within the small area at Camarones, there is a noticeable difference in the depth ranges of the transported faunas. Locality TU 1399 seems to be the most shallow but TU 1397 is moderately deep-water. In general, the same species of mol-

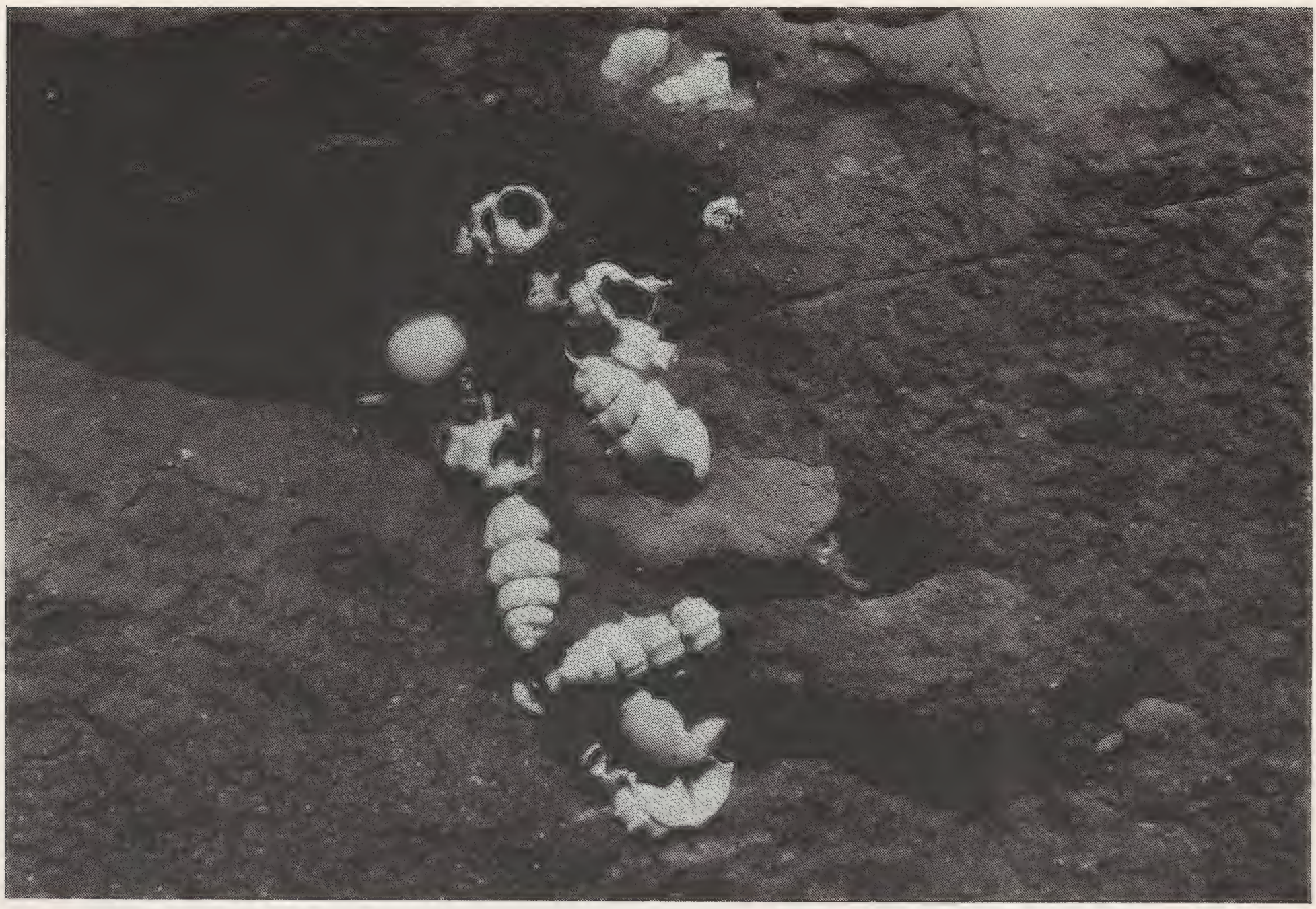
*For discussions of the currently accepted stratigraphical nomenclature in the area see Bristow, 1976, and Evans and Whittaker, 1982.

Text-figure 3. Punta Gorda, viewed from east, showing wave-cut platform exposed at low tide.

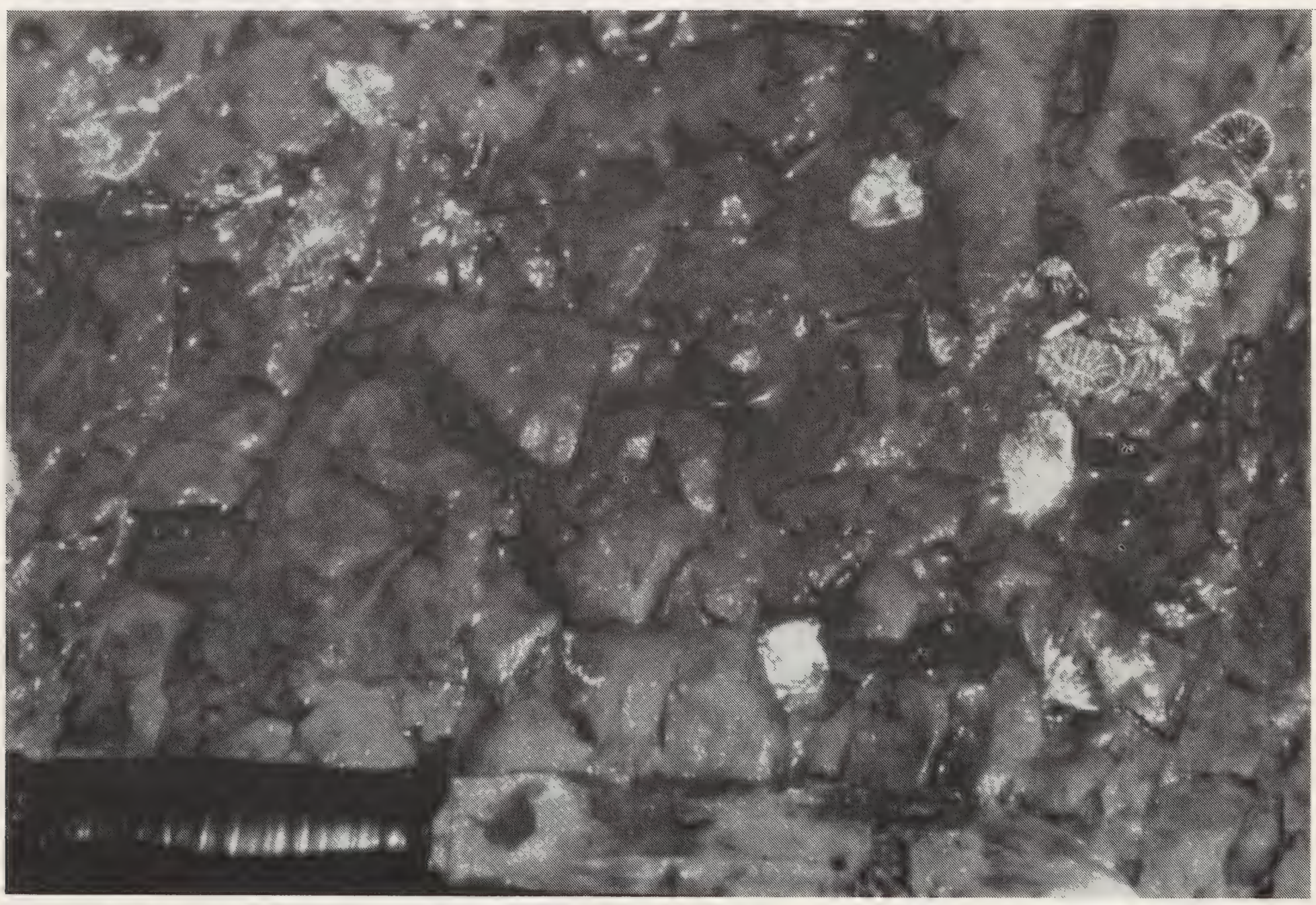
Text-figure 4. Burrowed beds of Onzole Formation, at Punta Gorda.

Text-figure 5. Burrow in Onzole Formation, Punta Gorda.

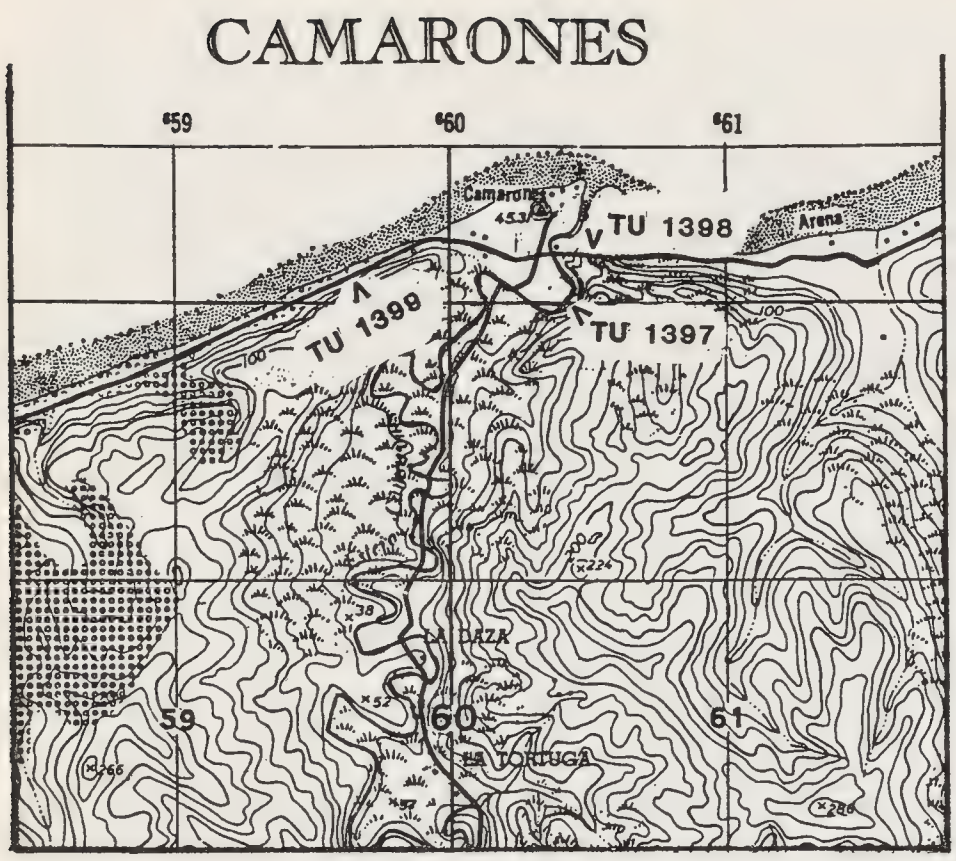
Text-figure 6. Burrow in Onzole Formation, Punta Gorda.



Text-figure 7. Cluster of specimens of *Profundinassa*, perhaps filling a burrow; Onzole Formation, Punta Gorda.



Text-figure 8. Specimens of *Flabellum*, a solitary coral; Onzole Formation, Punta Gorda.



Text-figure 9. Map of Camarones area, northwestern Ecuador; showing Tulane University (TU) collecting localities.

lusk occur at both places, but in differing quantities. For example, at TU 1399 various species of *Oliva* are abundant (62 specimens, in contrast to 5 at TU 1397) but *Cantharus scissus* Olsson is rare at TU 1399 (4 specimens) and common at TU 1397 (45 specimens). A closely related living species is one that Olsson named as type of a new subgenus, *Cantharus (Muricantharus) panamicus* (Hertlein and Strong), in a subsequent work (Olsson, 1971, p. 61), where he noted the depth of the living species averages 73 meters.

Thus, we may postulate that at locality TU 1399 the original slide began in relatively shallow water, almost intertidal, sweeping down into depths of perhaps 1000 m; but the slide at TU 1397 began in somewhat deeper water, on the order of 75 m, then washed into the deeper water.

Inasmuch as the Esmeraldas fauna is Early Pliocene in age, it should be closely allied with a correlative sequence in the Dominican Republic, where we have been working several years (Vokes, in press). The beds in the Dominican Republic contain facies from shoreline (Bulla Conglomerate) through shallow-water (Cercado Formation) to deep-water (Gurabo Formation) and ecologically are very nearly identical to the Esmeraldas beds. One would expect the faunas also to be nearly identical but they are not.

In his 1964 study, Olsson included five muricid species (one only as "unnamed turrid sp.") from the Esmeraldas beds, one from the Picaderos Formation and two from the Angostura Formation. Of these, all have now been found in the Esmeraldas beds except *Eupleura* sp. cf. *thompsoni* Woodring, which we have taken at Punta Verde, in the Angostura Formation.

Our work has added 14 additional muricid taxa, but, contrary to the anticipated results, there is just one species in common with the Dominican fauna, and only eight of the 21 occur in any other Pliocene faunas. Two of these, *Hexaplex brassica* and *Vitularia salebrosa* (as *ecuadorana*) are from the Pacific coast. The others are Caribbean: *Murex polynematicus* and *Typhis latipennis* from the Gatun Formation, Panama; *Chicoreus (Phyllonotus) globosus, Hexaplex hertweckorum,* and *Muricopsis oxytata* from the Pinecrest and Caloosahatchee units of southern Florida; *Vitularia salebrosa* again (as *linguabison*) from the Pinecrest beds and the Agueguexquite Formation of Mexico; and *Typhis alatus* from the Gurabo Formation, Dominican Republic, and the Gatun Formation, Panama. The largest number of taxa in common with another fauna is 11, which are still living in the eastern Pacific.

Table I shows the species involved and their affiliations. The prefix "R" indicates species occurring in the Recent Pacific fauna, but an asterisk indicates those that no longer live on the Ecuadorian coast. A lower case "r" indicates living Atlantic species.

In overall makeup, the majority of the Esmeraldas fauna is indeed allied with the Caribbean province, 12 of the muricid species have unmistakable Caribbean relatives. Of these, three are from the "Gatunian," or "southern Caribbean province" but three are from the "Caloosahatchian," or "northern Caribbean province," suggesting that Petuch's (1982, p. 282) conclusions on the origins of the eastern Pacific fauna as exclusively "Gatunian" may be unwarranted. Three taxa represent world-wide Eocene (Tethyan relics) and two species apparently came directly from West Africa, which is not unexpected

TABLE 1.
ELEMENTS OF THE MURICID FAUNA OF THE "ESMERALDAS BEDS"

I. Caribbean
1. (R) MUREX (HAUSTELLUM) RECURVIROSTRIS (Charco Azul Formation)
2. MUREX (HAUSTELLUM) POLYNEMATICUS (Gatun Formation)
3. (R)* MUREX (?HAUSTELLUM) RUTHAE, n. sp.
4. (r) CHICOREUS (PHYLLONOTUS) GLOBOSUS (Pinecrest beds and Caloosahatchee Formation; Recent, Venezuela)
5. CHICOREUS (PHYLLONOTUS) sp.
6. (R)* ATTILIOSA NODULOSA
7. (r) MURICOPSIS OXYTATA (Pinecrest beds, Caloosahatchee and Bermont formations; Recent, western Atlantic)
8. (R) MUREXIELLA LAPPA
9. (R)* ACANTHOTROPHON SORENSENI
10. (R) VITULARIA SALEBROSA (Daule and Charco Azul formations, Pinecrest beds, and Agueguexquite Formation)
11. (R)* TYPHIS (TALITYPHIS) LATIPENNIS (Gatun Formation)
12. TYPHIS (TALITYPHIS) ALATUS (Gurabo and Gatun formations)

II. World-wide Tethyan relics, probably Caribbean
1. (r) POIRIERIA (POIRIERIA) ACTINOPHORA (Recent, western Atlantic)
2. (R)* POIRIERIA (PAZIELLA) MERIDIONALIS (as GALAPAGANA in Recent)
3. MUREXSUL PITTI, n. sp.

III. California-Northern Pacific
1. CERATOSTOMA NOTIALE , n. sp.
2. (R)* PTEROPURPURA (PTEROPURPURA) MARKSI (as TRIALATA in Recent)
3. PTEROPURPURA (OCINEBRELLUS) ECUADORIA

IV. Direct from West Africa?
1. (R) HEXAPLEX BRASSICA (Charco Azul and Jama formations)
2. (r) HEXAPLEX HERTWECKORUM (Pinecrest beds; as H. DUPLEX in Recent, eastern Atlantic)

V. Endemic?
1. (R) HEXAPLEX AMBIGUUS

21 species total

R – living in eastern Pacific; *no longer on Ecuador coast

r – living in Atlantic

in light of similar distribution in genera such as *Harpa (H. doris* in Africa, *H. crenata* in eastern Pacific) and *Purpurellus (P. gambiensis* in Africa, *P. pinniger* and *P. macleani* in eastern Pacific). Both of these genera are good examples of "paciphiles" with representatives in the Gurabo Formation of the Dominican Republic, but no longer extant in the western Atlantic. Three taxa are clearly from a more northern Pacific province and are most closely related to living cooler-water species of California and Japan. This corroborates the findings of Hasson (*in* Jones and Hasson, 1985, p. 345), who noted the changes in microfauna from the tropical Miocene "Borbón Formation" [*i.e.* lower Onzole] to the temperate Pliocene "Punta Gorda Formation" [*i.e.*, Esmeraldas beds], which has a microfauna similar to that of California.

Although 11 species (or their very close descendants) still live in the eastern Pacific, six of these are no longer in the Esmeraldas area. Presumably the loss of the Caribbean current after closure of the seaway changed the temperature just enough that some of the species now do not extend as far south. The Ecuador-Peru border is essentially the boundary between the

Text-figure 10. Cut-bank on Rio Camarones; TU locality 1397.

Text-figure 11. Large blocks fallen from above; TU locality 1397.

Text-figure 12. Exposure in road-cut at mouth of Rio Camarones; TU locality 1398.

Text-figure 13. Detail of "escape structure" in beds shown above; TU locality 1398.

Tropical East Pacific and the cooler-water Peruvian Province. The mollusk fauna of Ecuador is at the southern extremity of the Tropical province and would be expected to show a diminution in numbers.*

As Jones and Hasson (1985, p. 350) have indicated, the question of how rapidly populations separated by a geographic barrier diverge is central to the process of speciation. Considering the large proportion of still living forms in the Pliocene Esmeraldas beds, it would seem that a longer period than just 3.5 million years was necessary to evolve the array of cognate species that are present in the Tropical Eastern Pacific Province as a whole. Thus, although the Atrato Strait was closed last, it seems probable that the majority of the elements were already in place before the Pliocene and were initially introduced farther north, probably in the Costa Rica region.

This is demonstrated by the *Murex messorius* complex, which by the Early Pliocene had already differentiated into *M. recurvirostris* and, presumably, the northern *M. lividus* and *M. tricoronis* as well. The form that has been called "*Murex elenensis*" in the Gulf of California is not that species and is here named *Murex ruthae*. It is this member of the lineage that occurs at Esmeraldas, suggesting that it is the ancestral form from which the living *M. elenensis* evolved.

But the most striking case is that of *Hexaplex ambiguus*. Although the shell cited under that name by Olsson (1964, p. 138, pl. 29, fig. 5) is not *H. ambiguus*, true *H. ambiguus* also occurs in the Esmeraldas beds. The origin of this species complex (*H. radix, nigritus,* and *ambiguus*) is obscure, and until now it was assumed to have been derived from *H. hertweckorum* (*H. fulvescens* of authors). Discovery of an example of *H. ambiguus* occurring with *H. hertweckorum* in the Esmeraldas beds casts doubt upon this idea. Regardless of the origin, presumably western Africa, the separation of the *H. hertweckorum-H. ambiguus* lines must have preceded the Esmeraldas fauna by considerable time. Again, the entry point for the *H. ambiguus* line was almost certainly the Costa Rica area. Today, *H. ambiguus* extends northward from Costa Rica to the Gulf of California, where *H. nigritus* occurs sympatrically in the northern portion of the range. Southward, it extends to Ecuador, but in the Bay of Panama it is found sympatrically with a local descendant, *H. radix*.

In the Recent fauna of Ecuador there are several muricid groups for which there is no known Esmeraldas equivalent. Some of this is an artifact of collecting, but the groups that have not been found represent ancient lines (*e.g.*, *Homalocantha, Favartia,* and *Purpurellus*), which occur in the Lower Miocene of the western Atlantic and which would have been presumed to have made the move into the Pacific earlier than some of the other groups. Although *Favartia* still lives in the Caribbean, both *Homalocantha* and *Purpurellus* no longer occur there but are still living in West Africa.

One final observation on the composition of the Tropical East Pacific muricid fauna is the inexplicable *lack* of certain groups that are well-represented in the Caribbean fauna. These include *Chicoreus* s.s., *Chicoreus (Siratus), Pterynotus* s.s. and *Poirieria (Panamurex)*. These groups have numerous species in both the fossil and living Caribbean faunas, but for some reason never made the transition to the East Pacific Coast.

III. ACKNOWLEDGMENTS

This study has been in progress for a number of years, since our first visit to Esmeraldas in 1982, and has involved the reevaluation of a number of Recent species from both the western Atlantic and the eastern Pacific, in addition to the expected fossil species. As a result, the writer is indebted to an unusually large number of persons, from various institutions, including John Taylor and Kathie Way, of the Mollusca Section, British Museum (Natural History), for their kindness while work was being done at the Museum and subsequently; and Peter Jung, of the Naturhistorisches Museum, Basel, Switzerland, for the use of his Esmeraldas collections. For the loan of specimens she is

*Of the 75 West Coast species of muricid listed by Keen (1971, pp. 514-524; excluding Galápagos endemics) only 22 are found in Ecuador. Of these, two are confined to the Ecuador-Peru area, the other 20 extend as far north as Mexico.

grateful to the late Joseph Rosewater, M.G. Harasewych, Thomas R. Waller, and Warren Blow, all of the United States National Museum of Natural History; James McLean and Gale Sphon, Los Angeles County Museum of Natural History; Peter R. Hoover, Paleontological Research Institution, Ithaca, New York; and Elana Benamy, Academy of Natural Science, Philadelphia. The late Ruth Purdy, San Diego, California, was always extremely generous with Mexican Recent material, much of which is figured herein. Other colleagues, who provided a variety of information concerning ages of formations, as well as location, etc., of type specimens, include: Roger Bristow, British Geological Survey, Exeter, England; W.H. Akers, formerly of Chevron USA, now retired, and Barry Kohl, also of Chevron USA, New Orleans; Robert H. Stewart, formerly of the Panama Canal Company, now retired; Ruth Turner and Ronald Eng, of the Harvard Museum of Comparative Zoology; Michael Kellogg, California Academy of Sciences; William K. Emerson, American Museum of Natural History, New York; Richard Preece, University Museum of Zoology, Cambridge; and Patrick Nuttall, British Museum (Natural History). Finally, William and Lois Pitt, Sacramento, California, deserve the greatest thanks of all, for locating the sites originally, collecting much of the material, and for being delightful field companions.

Abbreviations for Repository Institutions

ANSP - Academy of Natural Sciences, Philadelphia
BMNH - British Museum (Natural History)
CAS - California Academy of Sciences
LACM - Los Angeles County Museum of Natural History
NMB - Naturhistorisches Museum, Basel, Switzerland
PRI - Paleontological Research Institution
UCMP - University of California, Berkeley, Museum of Paleontology
USNM - United States National Museum of Natural History

IV. SYSTEMATIC PALEONTOLOGY

Class GASTROPODA
Order NEOGASTROPODA
Superfamily MURICACEA

Family MURICIDAE Rafinesque, 1815
Subfamily MURICINAE Rafinesque, 1815
Genus MUREX Linnaeus, 1758

Murex LINNAEUS, 1758, Syst. Nat., ed. 10, p. 746.

Type species: *Murex tribulus* Linn., 1758, by subsequent desig., Montfort, 1810.

Subgenus HAUSTELLUM Schumacher, 1817

Haustellum SCHUMACHER, 1817, Essai Nouv. Syst. Vers Test., p. 213.

Type species: *Murex haustellum* Linn., 1758, by tautonomy.

MUREX (HAUSTELLUM) RECURVIROSTRIS Broderip
Plate 1, figs. 1, 2

Murex recurvirostris BRODERIP, 1833, Zool. Soc. London, Proc., pt. 2, p. 174; SOWERBY, 1834, Conch. Illus., *Murex*, pl. 59, fig. 9; REEVE, 1845, Conch. Icon., v. 3, *Murex*, pl. 19, fig. 75; SOWERBY, 1879, Thes. Conch., v. 4, *Murex*, fig. 16; TRYON, 1880, Man. Conch., v. 2, p. 80 (in part), pl. 11, fig. 193 only; OLSSON, 1942, Bulls. Amer. Paleontology, v. 27, no. 106, pp. 163, 171; KEEN, 1958, Sea Shells Trop. West Amer., ed. 1, p. 352, fig. 336; KEEN, 1971, *ibid.*, ed. 2, p. 514, fig. 976; RADWIN and D'ATTILIO, 1976, *Murex* Shells of the World, p. 70, pl. 11, fig. 11; FAIR, 1976, *Murex* Book, p. 71, pl. 3, fig. 28; D'ATTILIO and HERTZ, 1979, Festivus, v. 11, no. 8, p. 61, figs. 3, 5; not fig. 6 (= *M. lividus* Carpenter).

Murex (Murex) recurvirostris Broderip. HERTLEIN and STRONG, 1955, Amer. Mus. Nat. Hist., Bull., v. 107, Art. 2, p. 252.

Murex (Haustellum) recurvirostris Broderip. VOKES, 1984, Shells and Sea Life, v. 16, no. 11, p. 210, back cover color photo.

INCORRECT REFERENCES TO *M. recurvirostris:*

Murex recurvirostris Broderip. GABB, 1873, Amer. Phil. Soc., Trans., (N.S.) v. 15, pt. 1, p. 201; PILSBRY, 1922, Acad. Nat. Sci. Phila., Proc., v. 73, p. 353 (Baitoa, Cercado, and Gurabo formations, Dominican Republic = *M. messorius* Sowerby).

Murex recurvirostris Broderip. GABB, 1881, Acad. Nat. Sci. Phila., Jour., (Ser. 2) v. 8, pt. 4, p. 349 (Moín Formation, Costa Rica = *M. olssoni* Vokes).

Murex recurvirostris Broderip. BAKER 1890, Acad. Nat. Sci. Phila., Proc., v. 42, p. 70, fig. 9 (protoconch); M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 2 (in part), pl. 1, fig. 2 (Recent, "Dominican Republic"),

text-fig. k (after Baker, 1890) (= *M. rectirostris* Sowerby).

Murex (Murex) recurvirostris Broderip. WOODRING, 1928, Carnegie Inst. Washington, Publ. 385, p. 288, pl. 17, figs. 7, 8 (Bowden Formation, Jamaica = *Chicoreus (Siratus) formosus* Sowerby).

Murex recurvirostris Broderip. RUTSCH, 1934, Schweizer. Paleont. Gesell., Abh., v. 54, no. 3, p. 64, pl. 4, fig. 1; v. 55, no. 1, p. 136 (Pta. Gavilan Formation, Venezuela = *M. donmoorei* Bullis).

Murex recurvirostris Broderip. WOODRING *in* DURHAM, *et al.*, 1955, Geol. Soc. Amer., Bull., v. 66, p. 984 ("Coatzacoalcos Formation," Mexico = *M. messorius* Sowerby).

Murex recurvirostris Sowerby *[sic]*. KAICHER, 1957, Indo-Pacific Sea Shells, Muricacea, Buccinacea, pl. 2, fig. 6 (Recent, China, Japan = *M. rectirostris* Sowerby).

Murex (Murex) recurvirostris recurvirostris Broderip. WOODRING, 1959, U.S. Geol. Surv., Prof. Paper 306-B, p. 214, pl. 35, figs. 5, 8; pl. 36, figs. 11, 12 (Gatun Formation, Panama = *M. messorius* Sowerby).

Murex (Murex) recurvirostris Broderip. PERRILLIAT MONTOYA, 1960, Paleontologia Mex., no. 8, p. 21, pl. 3, figs. 10, 11 (Agueguexquite Formation, Mexico = *M. bellegladeensis* Vokes).

Murex (Murex) recurvirostris recurvirostris Broderip. WEISBORD, 1962, Bulls. Amer. Paleontology, v. 42, no. 193, p. 278, pl. 26, figs. 3, 4 (Mare Formation, Venezuela = *M. donmoorei* Bullis).

Murex (Murex) recurvirostris recurvirostris Broderip. PERRILLIAT [MONTOYA], 1972, Paleontologia Mex., no. 32, p. 79, pl. 39, figs. 5-9 ("Santa Rosa beds," Mexico = *Chicoreus (Siratus)* sp. or spp.)

Lectotype: BMNH 1964347 (here designated); height 55 mm, diameter 26 mm. (This is the specimen figured by Sowerby, 1834, pl. 59, fig. 9. According to Broderip, 1833, p. 174, the type is "long. 3, lat. 1 6/8 poll." or 76 mm in height and

---

PLATE 1

Figures — Page

1, 2. *Murex (Haustellum) recurvirostris* Broderip 13
1. (X 1 1/2) USNM 418037; height 30.8 mm, diameter 23.7 mm.
Locality: TU 1399; Esmeraldas beds, Ecuador.
2. (X 1 1/2) USNM 859918; height 39.8 mm, diameter 21.3 mm.
Locality: TU R-186; Palo Seco, Panama; Recent.

3. *Murex (Haustellum) messorius* Sowerby 16
(X 1 1/4) USNM 859919; height 54.4 mm, diameter (including spines) 27.8 mm.
Locality: TU R-109; Bahia de las Minas, Panama (Atlantic); Recent.

4, 5. *Murex (?Haustellum) ruthae* E. H. Vokes, n. sp. 18
4. (X 1 1/4) USNM 859920 (paratype B); height 47.6 mm, diameter (including spines) 24.3 mm.
Locality: Off Guaymas, Sonora, Mexico; Recent.
5. (X 1 1/4) USNM 418038 (paratype C); height (incomplete) 24.7 mm, diameter 22.0 mm.
Locality: TU 1397; Esmeraldas beds, Ecuador.

6. *Murex (Haustellum) polynematicus* Brown and Pilsbry 17
(X 1 1/4) UCMP 38138; height 44.6 mm, diameter 27.6 mm.
Locality: Unnamed formation; Dept. of Nariño, Colombia.

7, 8. *Hexaplex hertweckorum* Petuch 24
7. (X 1) USNM 645613; height 64.0 mm, diameter 43.5 mm.
Locality: TU 797; Pinecrest beds, Florida.
8. (X 1) USNM 643954; height 67.0 mm, diameter 45.0 mm.
Locality: Punta Gorda; Esmeraldas beds, Ecuador.

9. (X 1/2) *Hexaplex duplex* (Röding) 25
Vokes Coll.; height 125 mm, diameter 93 mm.
Locality: Off Dakar, Senegal; Recent.

10, 11. *Hexaplex ambiguus* (Reeve) 25
10. (X 3/4) USNM 859921; height 70.4 mm, diameter 64.0 mm.
Locality: TU R-173; Puntarenas, Costa Rica; Recent.
11. (X 1/2) USNM 418039; height (incomplete) 52.0 mm, diameter 63.5 mm.
Locality: TU 1399; Esmeraldas beds, Ecuador.

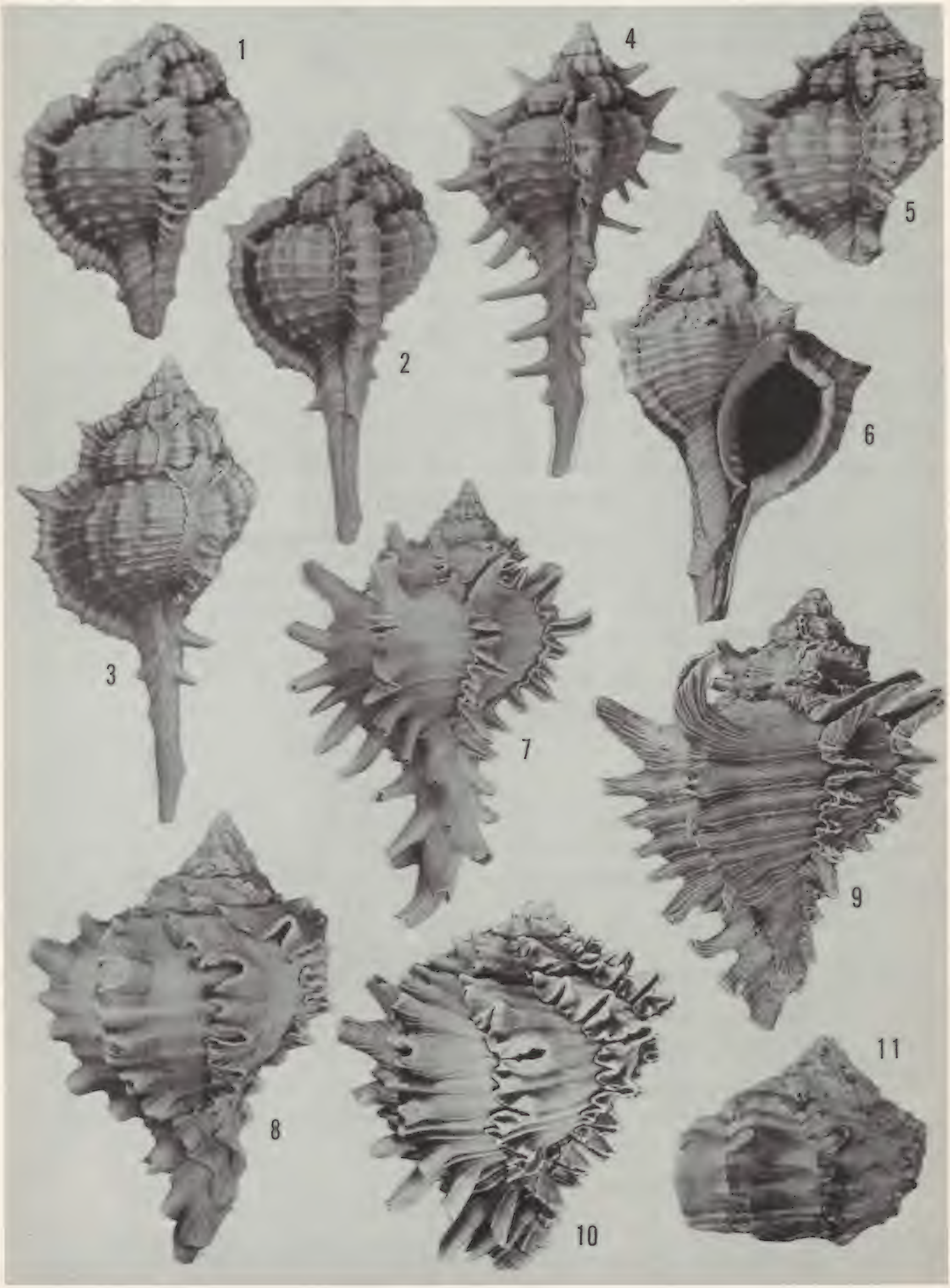


PLATE 1

44 mm in diameter. This is obviously a mistake, as one "poll." equals one inch and other measurements in the same paper agree with this interpretation. The largest specimen of *M. recurvirostris* seen by this writer is only 66 mm in height.)

Type locality: Gulf of Nicoya, Costa Rica.

Occurrence: Esmeraldas beds, Ecuador. Pleistocene, Panama. Recent, southern Mexico to Ecuador.

Figured specimens: Fig. 1, USNM 418037; height 30.8 mm, diameter 23.7 mm; locality TU 1399. Fig. 2, USNM 859918; height 39.8 mm, diameter 21.3 mm; locality TU R-186.

Discussion: Because *M. recurvirostris* was the first species of its group to be described from the New World there has been a tendency to use the name for every "*Murex*" species that occurs in the area, from Miocene to Recent, Atlantic or Pacific. Although Gabb (1873, 1881) was the first offender, the true culprit was Tryon (1880, p. 81) who included in synonymy: *M. messorius* Sowerby, 1841, with its synonyms, *M. funiculatus* Reeve, 1845, and *M. nigrescens* Sowerby, 1841, from the western Atlantic; *M. lividus* Carpenter, 1857, from the eastern Pacific; *M rectirostris* Sowerby, 1841, from the Indo-Pacific; and *Chicoreus (Siratus) articulatus* Reeve, 1845, (as "*motacilla* Sowerby") with its synonyms, *C. nodatus* (Reeve, 1845) and *C. antillarum* (Hinds, 1844) as well as *C. (S.) similis* (Sowerby, 1841) all from the western Atlantic.

It is little wonder that subsequent workers have been confused, as seen from the extended synonymy of *erroneus* references to *M. recurvirostris*. Among its eastern Pacific congeners, *M. recurvirostris* may be distinguished by the strong rugae on the inner lip, a trait not found in any other eastern Pacific species, nor in *M. rectirostris*, from the Indo-Pacific.

Atlantic species that have been included in synonymy are: *M. messorius; M. olssoni* Vokes, 1967; *M. donmoorei*, Bullis, 1964; and *M. bellegladeensis* Vokes, 1963. The latter lacks the labial rugae; the first three do have these rugae but both *M. olssoni* and *M. donmoorei* are much more spinose than *M. recurvirostris*. Only *M. messorius* is actually very close, and it may be distinguished by the lack of the deeply excavated varices characteristic of *M. recurvirostris*. In summary: *M. recurvirostris* has labial rugae, deeply excavated varices, and almost no spines; *M. messorius* has rugae and few spines, but no excavated varices; *M. olssoni* and *M. donmoorei* have rugae, many spines and no excavated varices; *M. bellegladeensis, M. lividus,* and *M. rectirostris* do not have labial rugae.

The ancestral form of this species-complex is the Atlantic *M. messorius*, which first appears in the Early Miocene Baitoa Formation, Dominican Republic. This species must have moved into the eastern Pacific relatively early, for the shell that occurs in the Esmeraldas beds is unequivocally referable to *M. recurvirostris* and not to *M. messorius* (*cf.* pl. 1, fig. 1, with figs. 2 and 3 - *recurvirostris* and *messorius*, respectively). The eastern Pacific species *M. lividus* is morphologically similar to the ancestral line, but lacks the labial rugae. The subspecies *M. lividus tricoronis* Berry, 1960, a more spinose form, also lacks the labial rugae. The latter two taxa are apparently confined to the Baja California and Gulf of California region; however, there are specimens from the Panama-Costa Rica area that are very similar to *M. lividus* or even *tricoronis*, in that they have spines, weakly excavated varices, and marked red spiral lines, but they retain the labial rugae. In fact, except for the red spiral lines, they are almost indistinguishable from the spinose forms of *M. messorius* that occur off Atlantic Panama (see Vokes, 1967a, pl. 2, especially fig. 6). The same form occurs in the Pleistocene Charco Azul Formation (TU 1499), suggesting that these atavists represent the remnants of the ancestral *messorius* line still surviving in the Panama region, as the original point of entry. From this species have evolved the northern *M. lividus* and *tricoronis*, losing the rugae, and *M. recurvirostris*, which has developed excavated varices.

In the collections from Esmeraldas, *M. recurvirostris* is not common, as we have a half-dozen, mostly broken, specimens. The species lives today in very shallow water (intertidal to about 7 m) and is interpreted as one of the transported members of the Esmeraldas fauna. Pilsbry and Olsson (1941) did not report this species from the Jama Formation, but Olsson did list it from the Charco Azul (1942b, p. 171) and Armuellas (*ibid.*, p. 163) formations of the Burica Peninsula. We have a number

of specimens from the Charco Azul, where they occur together with the above-mentioned forms of *M.* cf. *messorius,* in beds that also represent gravity-flows of shallower material into deep-water beds.

MUREX (HAUSTELLUM) POLYNEMATICUS
Brown and Pilsbry
Plate 1, fig. 6

Murex (Murex) polynematicus BROWN and PILSBRY, 1911, Acad. Nat. Sci. Phila., Proc., v. 63, p. 353, pl. 26, fig. 1; OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 137, pl. 29, figs. 2, 2a.

Murex (Murex?) polynematicus Brown and Pilsbry. WOODRING, 1959, U.S. Geol. Surv., Prof. Paper 306-B, p. 215, pl. 36, figs. 2, 3; pl. 37, figs. 6,9.

Murex (Murex) gilli polynematicus Brown and Pilsbry. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, p. 101, pl. 2, fig. 5.

Murex messorius Sowerby. VOKES, 1963, Tulane Stud. Geol., v. 1, no. 3, pl. 3, fig. 8 only (*not* of Sowerby).

Chicoreus (Siratus) gilli polynematicus (Brown and Pilsbry). VOKES, 1965, Tulane Stud. Geol., v. 3, no. 4, p. 183.

Not *Murex (Murex) polynematicus* Brown and Pilsbry. JUNG, 1965, Bulls. Amer. Paleontology, v. 49, no. 223, p. 520, pl. 69, fig. 6 (=*M. gilli* Maury).

Holotype: ANSP 1719; height 54.5 mm, diameter 33.7 mm.

Type locality: Gatun Formation; Gatun Locks, Panama.

Occurrence: Angostura Formation and Esmeraldas beds, Ecuador. Gatun Formation, Panama; unnamed formation, Nariño, Colombia; Pliocene.

Figured specimen: UCMP 38138; height 44.6 mm, diameter 27.6 mm; locality, Rio San Luis, 10 km south of confluence with the Rio Iseuande, Dept. of Nariño, Colombia.

Discussion: In 1963 the writer suggested that *M. gilli* (Maury, 1910) was so similar to *M. polynematicus* that the two could be separated only at the subspecific level. Since then she has examined much more material and has determined that *M. polynematicus* is a much larger species, with a lower spire and a smaller aperture than *M. gilli*, and there is a tendency toward a secondary varical spine at the periphery in *M. polynematicus*. These distinguishing features are readily apparent in the example figured by Jung (1965, pl. 69, fig. 6) from the Cantaure Formation of Venezuela, which is correlative with the Early Miocene Chipola Formation of Florida and not the Pliocene Gatun Formation, as he thought at the time. The Venezuelan specimen is better referred to *M. gilli,* in spite of the geographic proximity to *M. polynematicus.*

Woodring (1959, p. 214) stated that a specimen of what he termed "*Murex recurvirostris*" from the middle Gatun Formation had a protoconch of two and three-quarter whorls. It was this specimen (USNM 643766) that was figured by the writer as the protoconch of *M. messorius* (Vokes, 1963, pl. 3, fig. 8). Additional material has demonstrated that this shell is actually *M. polynematicus; M. messorius* has the one and one-half whorl protoconch Woodring attributed to the specimen of "*M. recurvirostris*" from the upper part of the Gatun Formation.

Both *M. messorius* and *M. polynematicus* occur in the Gatun Formation, although *M. messorius* is always less common than *M. polynematicus.* Thus, it was surprising to find in the Esmeraldas beds *M. polynematicus* with *M. recurvirostris* instead of *M. messorius.*

Given the very common occurrence of *M. polynematicus* in Panama (we have over 300 specimens from 6 localities: TU 757, 958, 961, 1431, 1432, 1433), one would expect that the species would still be living in the Caribbean, as most of its contemporaries are. But the line seems to be extinct. The nearest species is the Venezuelan *M. chrysostoma* Sowerby, 1834, which is also a member of the group of *M. gilli-polynematicus,* but which has been a separate species for at least as long as *M. polynematicus.* In the collections of the Museum of Paleontology, University of California, Berkeley, there are numerous Pliocene examples of *M. chrysostoma* from Isla Margarita, Venezuela.

The generic placement of this species has been a problem to the writer. Originally assigned to *Murex* s.s. (Vokes, 1963), it obviously does not belong there. Later (Vokes, 1965), all of the species assigned in 1963 to *Murex* s.s., which had deflected canals, were transferred to *Chicoreus (Siratus).* This left *M. gilli* and *M. polynematicus* in an awkward position, as they do not fit readily with either group. Since that time, the writer has worked extensively on the Indo-Pacific members of

Murex s.s. and, as a result (Ponder and Vokes, 1988), has come to the conclusion that *all* New World species formerly attributed to *Murex* s.s. are better placed in *Haustellum*. This removes the difficulties encountered with *M. gilli* and *M. polynematicus*, as they, of all the species involved, are the most closely akin to the type of *Haustellum (M. haustellum* Linnaeus). Unfortunately, it creates even more serious problems in the case of *M. cabritii* and *M. elenensis*, which must result from convergence of the New and Old World lines.

In the Esmeraldas collection, we have but one fragment of *M. polynematicus*, but the surface ornamentation is so characteristic there is no hesitation is assigning it to this species. The form was reported by Olsson from the type area of the Angostura Formation on the Rio Santiago and we have collected several examples of the species in the Angostura beds at Punta Verde (TU 1507), 20 km north-east of Rio Camarones. In the collections of the Berkeley Museum of Paleontology, there are several examples from Nariño, southern Colombia (see pl. 1, fig. 6) that are also referable to this species. This is a common form in the shallow-water Gatun Formation of Panama and is another of the transported members of the Esmeraldas fauna.

MUREX (?HAUSTELLUM) RUTHAE
E. H. Vokes, n. sp.
Plate 1, figs. 4, 5; Plate 2, figs. 1, 2.

Murex plicatus Sowerby. CARPENTER, 1857, Cat. Mazatlan, p. 518 (*not* of Sowerby).

Murex elenensis Dall. DURHAM, 1950, Geol. Soc. Amer., Mem. 43, p. 111, pl. 35, fig. 8; M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 2, pl. 4, fig. 2 (not fig. 12, as stated); KEEN, 1958, Sea Shells Trop. West Amer., ed. 1, p. 351, fig. 335; KEEN, 1971, *ibid.*, ed. 2, p. 514, fig. 975; DUSHANE and POORMAN, 1967, Veliger, v. 9, p. 428; DUSHANE and SPHON, 1968, Veliger, v. 10, p. 242; RADWIN and D'ATTILIO, 1976, *Murex* Shells of the World, p. 66 (in part), pl. 11, fig. 13 only (not pl. 13, fig. 1 = *M. tricoronis* Berry); FAIR, 1976, *Murex* Book, p. 39, pl. 3, fig. 3; D'ATTILIO and HERTZ, 1979, Festivus, v. 11, no. 8, p. 60 (in part), fig. 1 (not fig. 4 = *M. elenensis* Dall) (*not* of Dall).

Murex sp. cf. *elenensis* Dall. VOKES, 1984, Shells and Sea Life, v. 16, no. 11, p. 210, note 3.

Description: Shell with eight adult whorls, plus a protoconch of one and one-half rounded whorls, ending at a small, sharp, varix. Axial ornamentation on first three teleoconch whorls of nine or ten rounded ridges; by third or fourth teleoconch whorl every third ridge developed into a spined varix, three varices to each whorl, with the two intervening ridges remaining as intervarical nodes. Spiral ornamentation beginning with three equal cords, gradually adding alternate minor threads. On body whorl, six low rounded cords, all of approximately the same strength, alternating with smaller threads. Where the spiral cords cross the varices, spines produced; that at the shoulder the strongest, a slightly weaker one at the periphery, and two smaller ones between periphery and base of the body whorl. In addition, anterior to the two stronger spines, the two remaining spiral cords give rise to small spinelets. In young specimens varical spines nearly perpendicular to shell axis, but with increasing age these spines tend to bend forward and diminish in size, especially that at the periphery, until the shoulder spine and the anterior-most spine on the body whorl are the longest, with those between them greatly reduced. Aperture oval, inner lip smooth,

---

PLATE 2

Figures — Page

1, 2. *Murex (?Haustellum) ruthae* E. H. Vokes, n. sp. 18
1. (X 1) USNM 859922 (holotype); height 81.0 mm, diameter 37.2 mm.
Locality: Off Guaymas, Sonora, Mexico; Recent.
2. (Fig. 2a, X 1 1/4; fig. 2b, X 10) LACM 2247 (paratype A); height 34.9 mm, diameter 16.6 mm.
Locality: Between Loreto and Carmen Island, Baja California Sur, Mexico; Recent.

3, 4. *Murex (?Haustellum) elenensis* Dall 20
3. (X 1 1/4) USNM 859923; height 55.7 mm, diameter 29.5 mm.
Locality: TU R-478; Puerto de Cayo, Ecuador; Recent.
4. (X 1) BMNH 1964-351 (lectotype-*M. plicatus* Sowerby); height 80.0 mm, diameter (including spines) 42.8 mm.
Locality: Gulf of Nicoya, Costa Rica; Recent.

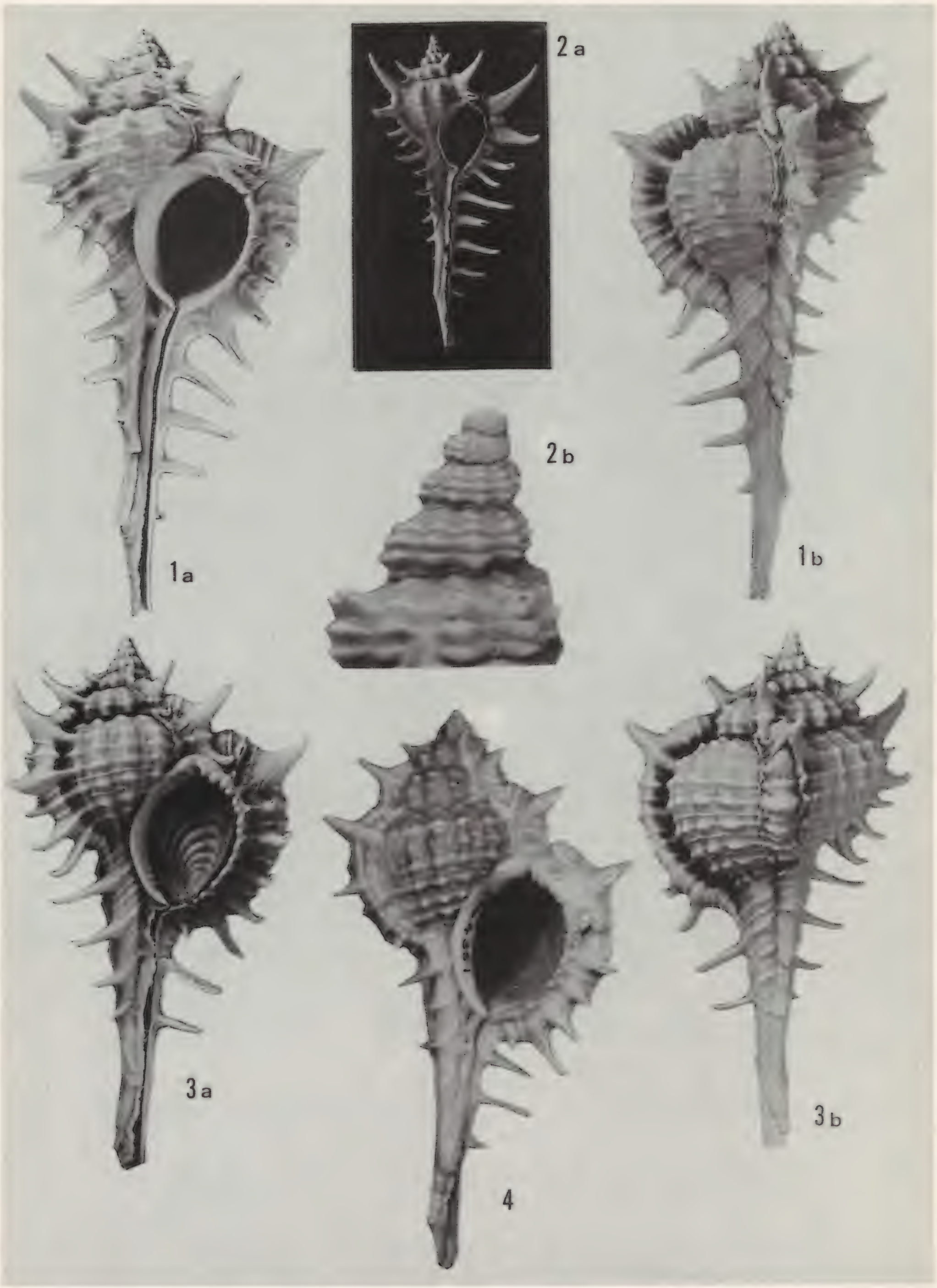


PLATE 2

free-standing anteriorly, appressed at posteriormost portion only. Outer lip crenulated along margin, otherwise smooth, except for a pair of nodes at posterior end, giving rise to a small anal notch. Siphonal canal long, straight, only slightly deflected at distal end; former canals fused into a tube, open by a narrow slit; ornamented by three rows of long spines, usually four in each row, rarely three or five. Color beige, with diffuse darker bands at the shoulder and base of the body whorl; rarely a third band at the periphery. Spiral cords topped with golden lines. Aperture white except for the darker bands showing through. Operculum reddish-brown, typically muricoid, with a terminal nucleus.

Holotype: USNM 859922; height 81.0 m, diameter 37.2 mm; locality, off Guaymas, Sonora, Mexico (shrimpers). (Plate 2, fig. 1)

Paratype A: LACM 2247; height 34.9 mm; diameter 16.6 mm; locality 27-45 m, channel between Loreto and Carmen Island, Baja California Sur, Mexico (Ariel Expedition, 29 August 1960). (Plate 2, fig. 2)

Paratype B: USNM 859920; height 47.6 mm, diameter 24.5 mm; locality, off Guaymas, Sonora, Mexico (shrimpers). (Plate, 1, fig. 4)

Paratype C: USNM 418038; height (incomplete) 24.7 mm, diameter 22.0 mm; locality TU 1397. (Plate 1, fig. 5)

Type locality: Channel between Loreto and Carmen Island, Baja California Sur, Mexico (locality of paratype A; the only one with certain locality data, most examples come from shrimpers and data are consequently rather vague. See ICZN Code art. 72(h)i.)

Occurrence: Esmeraldas beds, Ecuador. Pleistocene and Recent, Gulf of California only?

Discussion: The Gulf of California species that has universally been referred to *M. elenensis* Dall, 1909 (n. n. pro *M. plicatus* Sowerby, 1834, *non* Gmelin, 1791, etc.) is not the same as the typical form, which comes from Ecuador (Sta. Elena Bay – type locality of *M. elenensis*) to as far north as the Gulf of Nicoya (type locality of *M. plicatus*). This northern form is here named *M. ruthae* in honor of the late Ruth (Mrs. Ben) Purdy, who was always extremely generous with specimens and who contributed most of the material figured here. Comparison of the two forms shows that the Gulf of California species is larger, heavier, with a coarser sculpture. There are usually two (rarely three) intervarical nodes, in contrast to the three or four of *M. elenensis*, and the varices of the California shell are much less deeply excavated abaperturally. The spines of *M. ruthae* are longer, heavier, straighter, and extend farther down the siphonal canal.

Radwin and D'Attilio (1976, p. 66) included in the synonymy of "*Murex elenensis*," by which name they treated *M. ruthae*, both *M. lividus* Carpenter and *M. tricoronis* Berry. The principal similarity in the three forms is color: *M. lividus* has the diffuse dark bands of *M. ruthae* (lacking in true *M. elenensis); M. tricoronis* lacks the dark bands but has the gold-topped spiral cords. However, *M. lividus* has only short spines; *M. tricoronis* is more spinose but still has only one or two short spines on the siphonal canal, in contrast to the usually four of *M. ruthae*, as may be seen by comparing the illustrations in Radwin and D'Attilio (pl. 11, fig. 13 = *M. ruthae;* pl. 13, fig. 1 = *M. lividus tricoronis*).

This new species appears to be confined to the Gulf of California, usually in depths of 5 to 10 meters, and is taken mostly by shrimpers. The habitat of *M. elenensis* is essentially the same, but the species, so far as is known, does not get north of the Gulf of Nicoya, Costa Rica. Thus, it was a great surprise to find the Gulf of California species in the Esmeraldas beds, rather than the present day Ecuadorian form. In the collection from Esmeraldas, we have only two broken examples, but they lack the deeply excavated varices and "crisp" intervarical nodes of *M. elenensis* (*cf.* pl. 2, fig. 3b). It is assumed that *M. ruthae* is the ancestral form, which has now retreated to the Gulf of California, perhaps due to the warmer water there. If the presence of deeply excavated varices is parallel in *M. recurvirostris* and *M. elenensis* (which is by no means certain) then the non-excavated *M. messorius* and *M. ruthae* would represent the more "primitive" condition and the excavated forms the more "advanced."

Unfortunately, there is little fossil record for the New World *Murex* species-group with spinose canals. *Murex elenensis* occurs in the Pleistocene Charco Azul Formation of Panama (TU 1499). In the western Atlantic the cognate of *M. elenensis* is *M. cabritii* Bernardi, 1859. The only fossil occurrence of the latter is in the Pleistocene Moín Formation of Costa Rica (TU localitites 953, 954, 1240, and 1307).

Likewise, *M. ruthae* has been reported from the Pleistocene of Baja California (Durham, 1950, p. 111, pl. 35, fig. 8, as *M. elenensis* Dall, from Sta. Inez Bay). The occurrence in the Esmeraldas beds pushes the line back to the Early Pliocene but obviously the group has a much older history. It is assumed that these American spinose species are independently derived from the *M. messorius* stock and resemble the true *Murex* s.s. members of the Indo-Pacific region only as a result of convergence.

The presence of only these two incomplete examples in the Esmeraldas beds, together with the shallow habitat of the living forms, indicates this is another of the transported specimens in the fauna. The occurrence of this same form in the Gulf of California, together with the other species that are also confined to the area north of Panama today, suggests that the shallow water, at least, was probably warmer during Esmeraldas time than it is now.

Genus CHICOREUS Montfort, 1810

Chicoreus MONTFORT, 1810, Conchyl. Syst., v. 2, p. 611.

Type species: *Murex ramosus* Linn., 1758, by original desig.

Subgenus PHYLLONOTUS Swainson, 1833

Phyllonotus SWAINSON, 1833, Zool. Illus., (2) v. 3, expl. to pl. 100.

Type species: *Murex imperialis* var. *a* Swainson, 1833, by subsequent desig., Swainson, 1833 (*M. imperialis* var. *a* Swainson = *M. imperialis* Swainson, 1831, *non M. imperialis* Fischer, 1807 = *M. margaritensis* Abbott, 1958).

CHICOREUS (PHYLLONOTUS) GLOBOSUS (Emmons)

Plate 3, figs. 1, 2

Murex globosa EMMONS, 1858, Rept., North Carolina Geol. Surv., p. 247, fig. 105A.

Murex (Phyllonotus) pomum Gmelin. GARDNER, 1948, U.S. Geol. Surv., Prof. Paper 199, p. 219 (in part), pl. 29, figs. 22, 24; OLSSON and HARBISON, 1953, Acad. Nat. Sci. Phila., Mon. 8, p. 234 (in part), pl. 34, fig. 1 (*not* of Gmelin).

Phyllonotus globosus (Emmons). OLSSON and PETIT, 1964, Bulls. Amer. Paleontology, v. 47, no. 217, p. 549, pl. 82, fig. 2; FAIR, 1976, *Murex* Book, p. 46, pl. 9, fig. 120; PETUCH, 1976, Veliger, v. 18, p. 325, text-figs. 3, 5, 6.

Chicoreus (Phyllonotus) globosus (Emmons). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 148, pl. 4, figs. 1-3; pl. 5, figs. 1-3 (see for additional references for the species in western Atlantic); VOKES, 1984, Shells and Sea Life, v. 16, no. 11, p. 212, front cover color photo.

Phyllonotus cf. *globosus* (Emmons). PETUCH, 1987, New Caribbean Moll. faunas, p. 89, pl. 19, figs. 1, 2.

Holotype: not found.

Type locality: Waccamaw Formation; Cape Fear River (probably Neils Eddy Landing), Columbus County, North Carolina.

Occurrence: Esmeraldas beds, Ecuador. Pinecrest beds and Caloosahatchee Formation, Florida; Waccamaw Formation, North and South Carolina; ? Imperial Formation, California; Pliocene. Recent, Venezuela.

Figured specimens: Fig. 1, USNM 418040; height (incomplete) 29.0 mm, diameter (incomplete) 22.1 mm; locality TU 1397. Fig. 2, USNM 418041; height 45.3 mm, diameter 27.4 mm; locality TU 768.

Discussion: On the basis of the three fragmentary specimens we have of this species, it is presumed to be *C. globosus;* however, the possibility exists that it might be *C. pomum* (Gmelin, 1791). At this small size the two forms are difficult to distinguish, especially when as poorly preserved as the material at hand. They are definitely not the Recent eastern Pacific *C. peratus* (Keen, 1960), the cognate of *C. pomum,* as the Esmeraldas fragments clearly show no anal notch, no sharply pointed intervarical nodes and lack the shagreened surface of *C. peratus.*

Whether the fragments are referred to *C. globosus* or *C. pomum,* the implications are the same, as both are Caribbean species. The ancestor to both *C. pomum* and *C. peratus* is an undescribed species in the Dominican Republic, which has the body shape of *C. pomum* but the protoconch of *C. peratus.* It is unknown if it is also ancestral to *C. globosus,* but as there is not really any other contender we will assume that it is, as well as being ancestral to the other *Phyllonotus* species living on the West Coast: *C. regius* (Swainson, 1821) and *C. erythrostomus* (Swainson, 1831). (For a comparison of the various species the reader is referred to Vokes, 1984).

In the Pliocene beds of southern Florida *C. globosus* is a common species but today it is confined to the northern coast of Ven-

ezuela in shallow water (about 5 m). It is closely related to the similar *C. margaritensis* (Abbott, 1958) type of the subgenus, but differs from the latter in having only three or four varices in contrast to the five of *C. margaritensis;* it is also a lighter shell, with a higher spire. The more wide-spread *C. pomum* always has three varices and a relatively heavier shell.

Chicoreus (Phyllonotus) sp.
Plate 3, fig. 5

Figured specimen: USNM 418043; maximum diameter (as is) 29.0 mm; locality TU 1397.

Discussion: A single battered incomplete specimen from Quebrada Camarones is unlike any known species, bearing only a generic resemblance to the members of *Phyllonotus*. Undoubtedly, this is partly a result of the incomplete condition of the shell. But it is possible to see that, although the earliest whorls have been broken away and plugged by the animal in life, on the first whorls present the shell has a dozen axial nodes per whorl. By analogy with *C. erythrostomus*, to which it seems the most nearly related, this means that all of the earlier teleoconch whorls, three or four in number, were ornamented by twelve equal axial ridges and on the (probably) fifth post-nuclear whorl these began to develop into small varices, with three varices per whorl and two intervarical nodes between each pair.

This differs from *C. erythrostomus*, which develops four varices per whorl, with one node between each pair, and which also has a strong sharp spine at the shoulder of each varix. The varices in the fragment show no evidence of any spines but just raised welts where the spiral cords cross over. However, these two species have the same type of strongly projecting intervarical nodes, unlike those of the other three-varixed members of the group, such as *C. globosus*, *C. pomum* and *C. peratus*. The spire in the fragment is also lower than any of the known forms, only *C. erythrostomus* approaching the extremely inflated whorls of the Esmeraldas shell.

Genus HEXAPLEX Perry, 1810

Hexaplex PERRY, 1810, Arcana, expl. to pl. 23 (genus without species); 1811, Conchology, pl. 8.

Type species: *Hexaplex foliacea* Perry, 1811, by subsequent desig., Iredale, 1915 (= *Murex cichoreum* Gmelin, 1791).

PLATE 3

Figures — Page

1, 2. *Chicoreus (Phyllonotus) globosus* (Emmons) 21
1. (X 1 1/2) USNM 418040; height (incomplete) 29.0 mm, diameter (incomplete) 22.1 mm.
Locality: TU 1397; Esmeraldas beds, Ecuador.
2. (X 3/4) USNM 418041; height 45.3 mm, diameter 27.4 mm.
Locality: TU 768; Caloosahatchee Fm., Florida.

3, 4. *Hexaplex brassica* (Lamarck) 28
3. (X 3/4) ANSP 15205; height 89.0 mm, diameter (including spines) 74.6 mm.
Locality: Puerto Jama; Jama Fm., Ecuador.
4. (X 1 1/2) USNM 418042; length (as is) 25.0 mm, width (as is) 13.0 mm.
Locality: TU 1399; Esmeraldas beds, Ecuador.

5. *Chicoreus (Phyllonotus)* sp. 22
(X 1 1/2) USNM 418043; maximum diameter (as is) 29.0 mm.
Locality: TU 1397; Esmeraldas beds, Ecuador.

6, 7. *Acanthotrophon sorenseni* (Hertlein and Strong) 38
6. (X 2) USNM 418044; height 27.7 mm, diameter 18.1 mm.
Locality: TU 1399; Esmeraldas beds, Ecuador.
7. (X 1 1/2) CAS 9611 (holotype); height 32.2 mm, diameter (including spines) 20.0 mm.
Locality: Off Cabo San Lucas, Baja California Sur, Mexico; Recent.

8. *Acanthotrophon panamensis* (Olsson) 38
(X 1 1/2) USNM 701162 (holotype); height 32.0 mm, diameter (including spines) 25.3 mm.
Locality: Bay of Panama, Panama, 84 m; Recent.

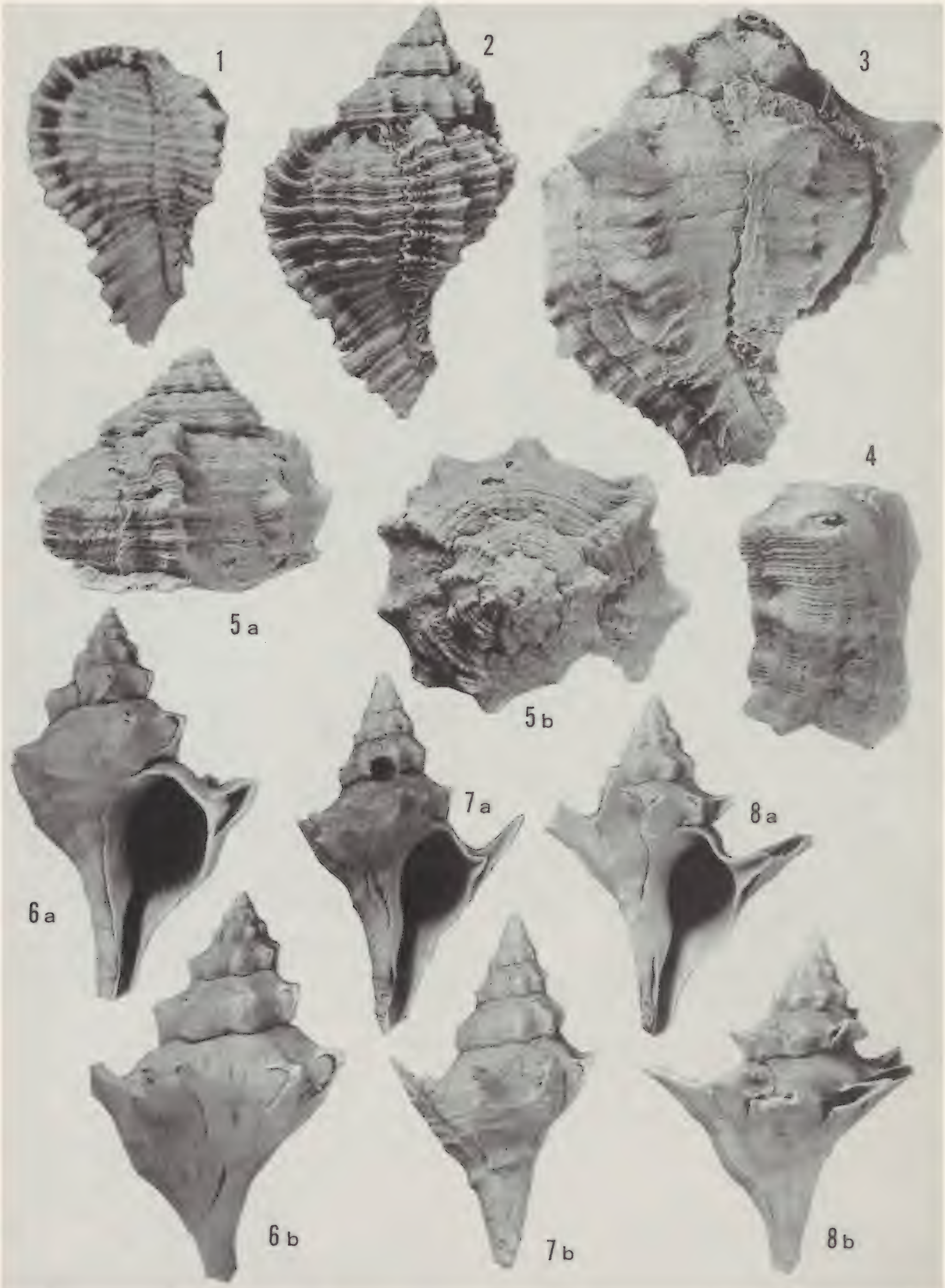


PLATE 3

Muricanthus SWAINSON, 1840, Treatise on Malacology, p. 296. New name for *Centronotus* Swainson, 1833, non Schneider, 1801 (Pisces).

Type species: *Murex radix* Gmelin, 1791, by subsequent desig., ICZN Opinion 911, 1970.

Discussion: The question of the validity of the subgenus *Muricanthus* is one that persists, as well as which species are to be included therein. Radwin and D'Attilio (1976, p. 75) included in *Muricanthus* several West African forms, as well as the New World forms usually placed herein. These authors, in fact, place only the type of *Hexaplex (H. cichoreum)* and *H. stainforthi* (Reeve, 1843) in *Hexaplex,* dividing the other possible members into various genera, especially *Phyllonotus,* although they give no reasons for the generic distinctions or rationale for which is placed where.

To this writer, if the taxon *Muricanthus* were to be considered valid, the only species assignable to it are the three eastern Pacific members of the "*Murex*" *radix* complex – *radix, ambiguus,* and *nigritus.* And, when one compares these with *H. cichoreum,* there is no morphologic basis upon which the two may be separated. The spines in *H. radix* and *H. nigritus* are short and spike-like but those of *H. ambiguus* are as frilly and recurved as many examples of *H. cichoreum.* Both "groups" have a labral tooth (well figured in Radwin and D'Attilio, 1976, text-figs. 27 and 44) and identical radulae (*ibid.,* text-figs. 26 and 43). Both have dark and light spiral stripes. In short, there is no reason that can be singled out to justify separation.

Curiously, the Panamic *H. radix* seems to have made its way into the Atlantic waters of the Lesser Antilles. Originally described as *Murex strausi* by Verrill (1950, p. 4) from Dominica, the illustration (a rather bad drawing) looked too much like *H. radix* for anyone to take seriously. More recently, Sutty (1986, p. 57, fig. 57) reported two examples from 21 feet (6.4 m) off Martinique. Her excellent color photographs show a small shell (32 mm) that is identical to juvenile specimens of *H. radix* of the same size. There may be a colony of *H. radix* in the Lesser Antilles but personally the writer suspects the hand of man was involved in some fashion.

HEXAPLEX HERTWECKORUM (Petuch)
Plate 1, figs. 7, 8

Muricanthus ambiguus (Reeve). OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 138, pl. 29, fig. 5 (*not* of Reeve).

"*Muricanthus ambiguus* (Reeve)" Olsson. VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 87 (*not* of Reeve).

Hexaplex (Hexaplex) fulvescens (Sowerby). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 104 (in part), pl. 3, fig. 1; pl. 4, figs. 1,2 only (*not* of Sowerby).

Muricanthus hertweckorum PETUCH, 1988, Bull. Paleomalacology, v. 1, no. 1, p. 18, pl. 3, figs. 1-3.

Holotype: USNM 424261; height 40 mm, diameter 35 mm.

Type locality: APAC Pit (Macasphalt Pit #0800826), Sarasota, Florida (= TU 1000).

Occurrence: Esmeraldas beds, Ecuador. Pinecrest beds, Florida; Pliocene.

Figured specimens: Fig. 7, USNM 645613; height 64.0 mm, diameter 43.5 mm; locality TU 797. Fig. 8, USNM 643954; height 67.0 mm, diameter 45.0 mm; locality, Punta Gorda, Ecuador.

Discussion: In the Pliocene Pinecrest beds of southern Florida there are numerous examples of a species that this writer earlier (Vokes, 1968) referred to *H. fulvescens.* However, the two forms are not identical, differing in the nature of the spines. *Hexaplex fulvescens* has straight, pointed spines, which are very nearly closed, leading to placement in the subgenus *Muricanthus* by some. However, the fossil specimens are more typically *Hexaplex,* with more open, distinctly recurved spines. In addition, the whorls of the fossil examples are more inflated and the spiral ornamentation is less pronounced. The Esmeraldas specimen that was referred to the Recent West Coast *H. ambiguus* (Reeve) by Olsson, differs from that species in much the same way. As can be seen from pl. 1, figs. 8 and 10, *H. ambiguus* has many more "prickly" spines, plus a labral tooth not found in the fossil example. In fact, this labral tooth is confined to those eastern Pacific species of the *H. radix* complex (*i.e., H. radix, ambiguus,* and *nigritus*) and does not occur in *H. fulvescens* or *H. princeps,* its eastern Pacific cognate.

Comparison of the Ecuadorian specimen with the Pinecrest material shows that they are identical, and are neither *H. fulvescens* nor *H. ambiguus.* The most closely

related form is the West African *H. duplex* (Röding, 1798), which differs solely in lacking the secondary spines between the shoulder and the suture (see pl. 1, fig. 9). It would appear that members of this species traveled more or less directly to the eastern Pacific from West Africa, but at the same time another group moved northward into Florida. There they flourished for a time, as we have numerous examples from many different Pinecrest localities (especially TU 1000, where it is common). But then it seemingly disappeared during the Late Pliocene Caloosahatchee time (we have no examples in our collections) and reappears in the Early Pleistocene Bermont Formation as true *H. fulvescens*. It is still very rare during this time, as we have it from only one Bermont locality (TU 578). Presumably, the lack of the form during the interval between the Pinecrest and the Recent is a result of environment. The Pinecrest is a muddy-sand/sandy-mud, similar to the modern environment of the living *H. fulvescens*, and most of the Caloosahatchee and Bermont localities are carbonate banks.

It is true that there are specimens, especially young examples, of *H. fulvescens* that get very close to the Pliocene form but, in general, the two species are readily separable. (One assumes that if any Late Pliocene examples are ever found they will be maddeningly intermediate.) Nevertheless, there is no known ancestor for the line in the Caribbean prior to the appearance of these Pinecrest specimens, and the line almost certainly came directly from West Africa. On the West Coast, there is no living representative of this line, unless it is *H. princeps* (Broderip, 1833), which still occurs in Ecuador, but which is noticeably different.

Hexaplex ambiguus (Reeve)
Plate 1, figs. 10, 11

Murex ambiguus REEVE, 1845, Conch. Icon., v. 3, *Murex*, pl. 13, fig. 51; REEVE, 1846, Zool. Soc. London, Proc., pt. 13, p. 86.

Murex nitidus Broderip. REEVE, 1845, Conch. Icon., v. 3, *Murex*, pl. 17, fig. 70 (? not of Broderip).

Murex (Phyllonotus) nigritus "Meusch." [= Philippi]. CARPENTER, 1857, Cat. Mazatlan, p. 521 (in part).

Murex (Phyllonotus) nitidus Broderip. TRYON, 1880, Man. Conch., v. 2, p. 105 (in part), fig. 242 only.

Muricanthus ambiguus (Reeve). KEEN, 1958, Sea Shells Trop. West Amer., ed. 1, p. 354, fig. 343; KEEN, 1971, *ibid.*, ed. 2, p. 521, fig. 999.

Muricanthus callidinus BERRY, 1958, Leaflets in Malac., v. 1, no. 15, p. 84; KEEN, 1958, Sea Shells Trop. West Amer., ed. 1, p. 354, fig. 343a (= Reeve, fig. 70); KEEN, 1971, *ibid.*, ed. 2, p. 521, fig. 1000 (upper fig. = holotype; lower fig. = Reeve, fig. 70); DUSHANE and POORMAN, 1967, Veliger, v. 9, p. 428.

Not *Muricanthus ambiguus* (Reeve). OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 138, pl. 29, fig. 5 (= *H. hertweckorum*).

Hexaplex ambiguus (Reeve). VOKES, 1968, Tulane Stud. Geol., v. 6, no. 3, p. 87; FAIR, 1976, *Murex* Book, p. 20, pl. 12, fig. 149.

Muricanthus radix (Gmelin). RADWIN and D'ATTILIO, 1976, *Murex* Shells of the World, p. 77 (in part), pl. 12, fig. 1 only.

Holotype: Not found.

Type locality: Unknown.

Occurrence: Esmeraldas beds, Ecuador. Recent, Guaymas, Mexico (*fide* DuShane and Poorman, 1967, p. 428) to Paita, Peru (*fide* Hertlein and Strong, 1955, p. 257).

Figured specimens: Fig. 10, USNM 859921; height 70.4 mm, diameter 64.0 mm; locality TU R-173. Fig. 11, USNM 418039; height (incomplete) 52.0 mm, diameter 63.5 mm; locality TU 1399.

Discussion: There have been discussions since the time of Reeve as to whether the various forms of "Black *Murex*" that occur along the west coast of tropical America are all one species or three (even four) valid taxa. Reeve (1845, expl. to pl. 13) gives a long discussion, concluding: "The true *Murex radix* is a round particularly solid heavy shell with a short, though sharply acuminated spire, with not less than ten varices, in which the fronds are numerous, somewhat laterally compressed, comparatively short, and sharp pointed; the species described by Dr. Philippi under the title of *Murex nigritus* (for which see [Reeve, 1845] Pl. 12, Sp. 47), has but eight or nine varices and the fronds are not branched, those on the upper angle of the whorls being tubercularly squamate, those in the middle flat and very obscure, whilst those of the base are long and horn-shaped." He then described a new species, *Murex ambiguus*, stating: "The shell is of somewhat light structure

and the fronds are large, open, and flowery. It certainly presents a modification of character intermediate between the *Murices radix* and *nigritus* but is always easy to be distinguished."

Unknown to Reeve is that there is a valid geographic distribution of the three forms, even though it is not as simple as we once thought. Furthermore, it appears that *H. ambiguus* is the ancestral species for two local forms: *H. nigritus*, from the Gulf of California to as far south as the Gulf of Tehuantepec; and *H. radix*, only in the Bay of Panama. The ancestral *H. ambiguus*, however, lives throughout the entire length of the range. Here is a case where "geographic subspecies" is not the solution to the taxonomic problem, for the oldest name *(radix)* is confined to a small area and to use it as the primary taxon is misleading both geographically and stratigraphically. As the three forms are readily separable and, as the Laws of Nomenclature will not allow the stratigraphical solution of "*H. ambiguus* s.s.," "*H. ambiguus radix*" and "*H. ambiguus nigritus*" it seems best to accept the three as valid species.

A fourth name, *Muricanthus callidinus*, was erected by Berry, 1958, for the shell illustrated by Reeve (1845, pl. 17, fig. 70) as *Murex nitidus* Broderip. In this form, the spines are straighter than in the typical *H. ambiguus* but otherwise there are no discernable differences and *M. callidinus* is here considered as a synonym of *H. ambiguus*.

The juvenile specimen named by Broderip as *Murex nitidus* (1833, p. 176) and illustrated by Sowerby (1834, pl. 58, fig. 4), from "Real Llejos, Cent. Am." (= Corinto, Nicaragua) is probably a young example of *H. princeps*, as suggested by Sowerby (1841, p. 6) rather than "*M. callidinus*" as indicated by Reeve (1845, pl. 17, fig. 70). As Keen (1958, p. 358) noted, *Murex nitidus* "is apparently the young of one of the species of *Muricanthus*, but authors are not in agreement as to which one. We are saved the necessity of guessing, as the name is preoccupied by *M. nitidus* Pilkington, 1804."

The identification of the southern members of the group is confused. Reeve stated that his specimen of "*Murex radix*" (1845, pl. 17, fig. 69) was from "Bay of Caraccas,

---

PLATE 4

Figures — Page

1, 2. *Poirieria (Paziella) meridionalis* (Olsson) 32
- 1. (X 2) USNM 418045; height 27.4 mm, diameter 15.5 mm.
- 2. (X 3) USNM 418046; height 12.0 mm, diameter 7.9 mm.
  Locality of both: TU 1397; Esmeraldas beds, Ecuador.

3-5. *Poirieria (Poirieria) actinophora* (Dall) 29
- 3. (X 2 1/2) USNM 430478; height 20.6 mm, diameter (including spines) 14.3 mm.
  Locality: Virgin Islands, 550-600 meters; Recent.
- 4. (X 2 1/2) USNM 418047; height 18.2 mm, diameter 8.7 mm.
- 5. (X 2 1/2) USNM 418048; height 17.5 mm, diameter 9.3 mm.
  Locality of both: TU 1397; Esmeraldas beds, Ecuador.

6. *Murexsul pitti* E. H. Vokes, n. sp. 37
  (X 1 1/2) USNM 418049 (holotype); height 30.0 mm, diameter 19.5 mm.
  Locality: TU 1397; Esmeraldas beds, Ecuador.

7, 8. *Murexiella lappa* (Broderip) 37
- 7. (X 3) USNM 859924; height 14.7 mm, diameter 9.0 mm.
  Locality: TU R-166; Barra de Navidad, Jalisco, Mexico; Recent.
- 8. (X 3) USNM 418050; height 13.7 mm, diameter 8.0 mm.
  Locality: TU 1397; Esmeraldas beds, Ecuador.

9, 10. *Muricopsis oxytata* (M. Smith) 34
- 9. (X 2) NMB H 17338; height 28.0 mm, diameter 14.7 mm.
  Locality: K-493, Trans-Ecuadorian Pipeline; Esmeraldas beds, Ecuador.
- 10. (X 3) USNM 418051; height 19.3 mm, diameter 9.0 mm.
  Locality: TU 726; Caloosahatchee Fm., Florida.

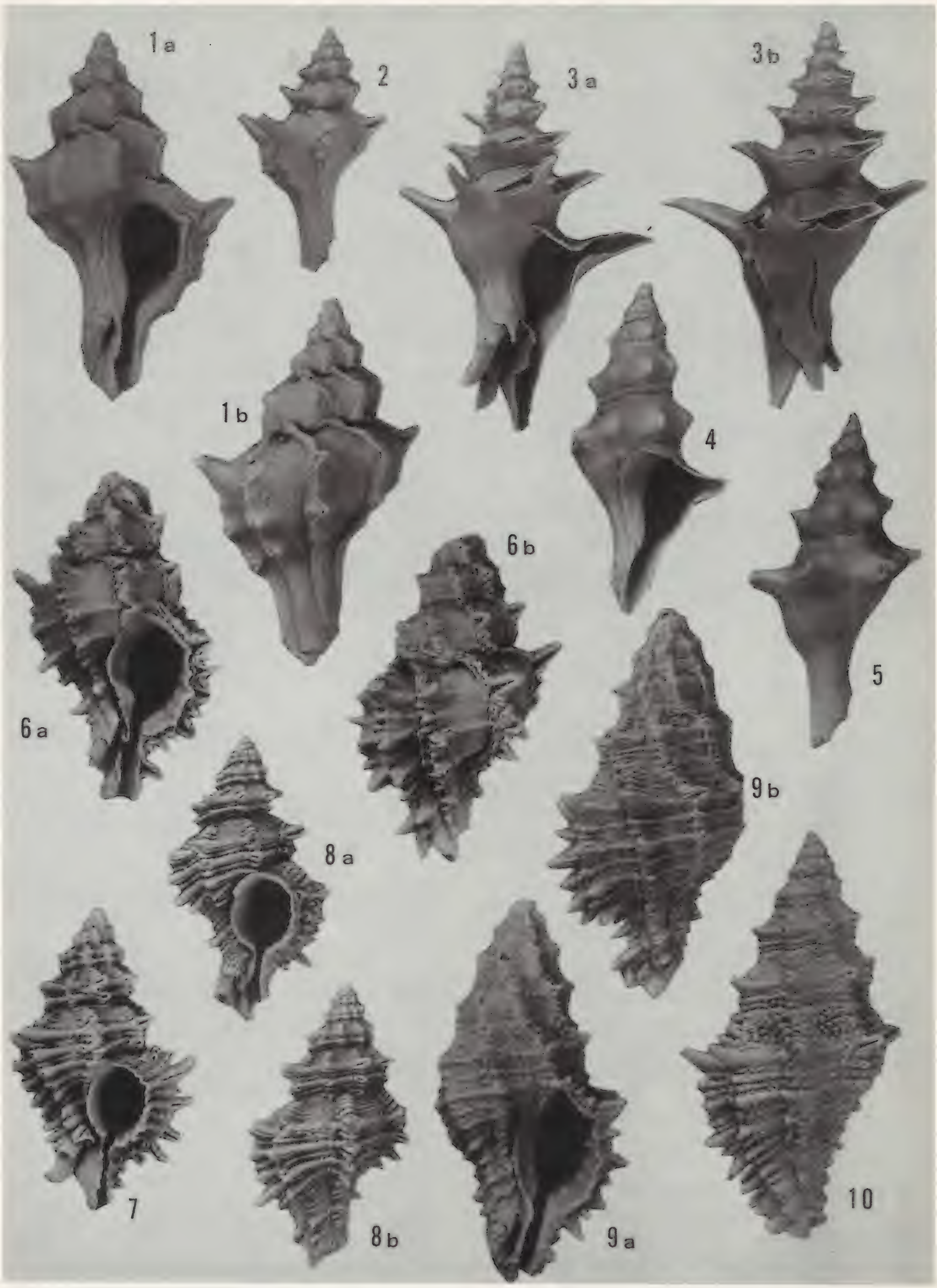


PLATE 4

West Colombia," which is assumed to be Bahía de Caraquez, just north of Manta, Ecuador. Other authors have cited "*radix*" as occuring from Panama to Ecuador (Keen, 1958, p. 356) or to Peru (Radwin and D'Attilio, 1976, p. 78; Hertlein and Strong, 1955, p. 257). Reeve's specimen appears to be typical *H. radix*, but the writer has seen no other examples, except from the Bay of Panama. Thus, there are three conclusions possible: the Reeve locality is incorrect, as are many others in the Cuming material; our intrepretation of where it is located is incorrect (no such name can now be found); or true *radix* does occur south of Panama. All southern specimens that we have collected (R-56, Tumaco, Colombia; R-381 and R-553, Sta. Elena Bay, Ecuador; R-552, Ayungue, Ecuador; and R-484, Camarones, Ecuador) are *H. ambiguus*.

In any case, the sole example of this group taken in the Esmeraldas beds is *H. ambiguus*, which would tend to confirm the idea that this is the ancestor from which the others diverged. The real problem is where did *H. ambiguus* originate? Only generically similar to the contemporaneous *H. hertweckorum*, the two must be assumed to have a earlier common ancestor. But there is no known form anywhere that would qualify. The only species that is remotely related is the common Indo-Pacific *H. cichoreum* (Gmelin, 1791), which shares the strong dark and light spiral banding, and a pronounced labral tooth. The spines of *H. cichoreum* are longer and more recurved and the maximum shell size is smaller, but otherwise the resemblance to *H. ambiguus* is stronger than anyone has ever been willing to admit. Perhaps this is because the two descendant forms, *H. radix* and *H. nigritus*, are much more distinctive.

This resemblance is further evidence that there is no justification for the recognition of *Muricanthus* (type species: *Murex radix*) as a valid subgenus. The only possible distinction is that "*Muricanthus*" has more varices than *Hexaplex* – the name "*Hexaplex*" is misleading, *H. cichoreum* has seven varices as often as six. But how many is enough to be "more?" Specimens of *H. fulvescens* may have from six to ten varices; *H. ambiguus* usually has about eight or nine; *H. nigritus* has six to eight; *H. princeps* has five to eight. Only *H. radix* itself would qualify, having more than ten, as a rule. Keen (1958, p. 356; 1971, p. 521, and personal communication) believed that the strongly looped anal notch of *H. cichoreum* was significant, but this varies even among members of the species *H. cichoreum* itself; some are strong, some almost invisible.

All living members of the group are inhabitants of very shallow water, usually from intertidal to as much as 30 m (Gulf of Tehuantepec–Don Shasky Coll.). This fits with the occurrence of this single Esmeraldas specimen at TU 1399, which is overall a much shallower fauna than is seen at the other localities.

HEXAPLEX BRASSICA (Lamarck)
Plate 3, figs. 3, 4

Murex brassica LAMARCK, 1822, Anim. s. Vert., v. 7, p. 167; SOWERBY, 1834, Conch. Illus., *Murex*, pl. 67, fig. 56; KIENER, 1843, Coq. Viv., v. 7, *Murex*, p. 68, pl. 26, fig. 1, pl. 27, fig. 1; REEVE, 1845, Conch. Icon., v. 3, *Murex*, pl. 14, fig. 56; SOWERBY, 1879, Thes. Conch., v. 4, *Murex*, fig. 166.

Murex ducalis BRODERIP and SOWERBY, 1829, Zool. Jour., v. 4, no. 15, p. 377.

Murex (Phyllonotus) brassica Lamarck. CARPENTER, 1857, Cat. Mazatlan, p. 523; TRYON, 1880, Man. Conch., v. 2, p. 100, pl. 22, fig. 200; M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 8, pl.4, fig.1.

Phyllonotus brassica (Lamarck). PILSBRY and OLSSON, 1941, Acad. Nat. Sci. Phila., Proc., v. 93, p. 37; OLSSON, 1942, Bulls. Amer. Paleontology, v. 27, no. 106, p. 169; RADWIN and D'ATTILIO, 1976, *Murex* Shells of the World, p. 88, pl. 16, fig. 5; FAIR, 1976, *Murex* Book, p. 27, pl. 10, fig. 124.

Hexaplex brassica (Lamarck). KEEN, 1958, Sea Shells Trop. West Amer., p. 352, fig. 338; KEEN, 1971, *ibid.*, ed. 2, p. 516, fig. 979; OLSSON, 1964, Neogene Moll. Northwest. Ecuador, pl. 29, fig. 4 (not in text); DUSHANE and POORMAN, 1967, Veliger, v. 9, p. 428.

Chicoreus (Phyllonotus) brassica (Lamarck). VOKES, 1967, Tulane Stud. Geol., v. 5, no. 3, p. 160; VOKES, 1984, Shells and Sea Life, v. 16, no. 11, p. 212.

Holotype: Not found.

Type locality: Mazatlan, Mexico (designated by Kiener, 1843, p. 69).

Occurrence: Jama Formation and Esmeraldas beds, Ecuador. Charco Azul Formation,

Panama; Pleistocene. Recent, Gulf of California to Peru.

Figured specimens: Fig. 3, ANSP 15205; height (incomplete) 89.0 mm, diameter (including spines) 74.6 mm; locality, Puerto Jama, Ecuador. Fig. 4, USNM 418042 (fragment); length (as is) 25.0 mm, width 13.0 mm; locality TU 1399.

Discussion: In the Esmeraldas collection there is a single fragment that can be referred without hesitation to an unmistakable species, "*Murex*" *brassica* Lamarck, 1822. This form was also reported by Pilsbry and Olsson (1941, p. 37) from the Pliocene Jama Formation of Ecuador and was figured by Olsson (1964, pl. 29, fig. 4) from beds that he considered to be Pliocene in age from the Burica Peninsula, Panama. The Burica beds are now known to be Pleistocene in age (R.H. Stewart, in litt., 24 Jan. 1985) but comparison of the Jama specimens (see pl. 3, fig. 3) and the Panamanian one shows no differences. Both the Pliocene and Pleistocene specimens do differ slightly from the usual appearance of Recent specimens in that the varices in the fossil examples are noticably stronger than in most Recent examples, where the varix is closely appressed to the whorl and scarcely visible except along the forward margin. However, this may be an ecologic factor, for specimens dredged from the Gulf of Chiriqui in 35-60 meters also have the stronger varices.

In an earlier paper (Vokes, 1967b, p. 160), the writer considered the problem of where to put *brassica* generically and concluded that the nature of the varices, lacking open spines, together with the strong labrum in front of the varix, much like that seen in *C. (P.) erythrostomus*, which also has a surface ornamentation similar to that of *brassica*, permitted (not mandated) placement in *Phyllonotus*. This was a compromise, for the form is distinctly intermediate between *Hexaplex* and *Phyllonotus*.

In terms of relationship, the only species closely related to *H. brassica* is the Mediterranean *H. trunculus* (Linnaeus, 1758). The generic placement of *H. trunculus* has also been a problem to many authors, some of whom have attempted to solve the problem by creating a new genus for the form. The names include *Purpura* Röding, 1798 (not *Purpura* Bruguière, 1789), *Truncularia* Monterosato, 1917 (not *Truncularia* Wiegmann, 1832), *Truncularіopsis* Cossmann, 1921 (new name for *Truncularia* Monterosato), and *Murithais* Grant and Gale, 1931. However, as the writer as discussed elsewhere (Vokes, 1968, p. 86), *H. trunculus* is just the end member of a group of muricids that goes back without change to the Eocene and cannot, in her opinion, be generically separated from *Hexaplex* s.s.

Obviously, *H. brassica* is descended from a West African form that made its way to the eastern Pacific without leaving a trace in the Caribbean. In the description of *H. etheringtoni* (Vokes, 1968, p. 102), it was suggested that perhaps this Colombian species was ancestral to the *H. brassica* line. However, the Tubará beds are now known to be Pliocene and not Miocene as originally thought, and are approximately contemporaneous with the Esmeraldas fauna. Thus, the two species probably represent different, although related, lineages. Nevertheless, both probably came directly from West Africa, as did *H. hertweckorum*.

Genus POIRIERIA Jousseaume, 1880

Poirieria Jousseaume, 1880, Le Naturaliste, Année 2, no. 42, p. 335.

Type species: *Murex zelandicus* Quoy and Gaimard, 1833, by original desig.

Actinotrophon DALL, 1902, U.S. Natl. Mus., Proc., v. 24, p. 534.

Type species: *Boreotrophon actinophorus* (Dall, 1889), by original desig.

Subgenus POIRIERIA s.s

Poirieria (Poirieria) actinophora (Dall)

Plate 4, figs. 3-5

Trophon (Boreotrophon) actinophorus DALL, 1889, Harvard Mus. Comp. Zool., Bull., v. 18, p. 206, pl. 15, fig. 2; DALL, 1889, U.S. Natl. Mus., Bull. 37, p. 120, pl. 15, fig. 2 (entire plate is copy of previous); M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 19, pl. 9, fig. 2 (after Dall).

Boreotrophon (Actinotrophon) actinophorus (Dall). DALL, 1902, U.S. Natl. Mus., Proc., v. 24, p. 534.

"Unnamed." OLSSON, 1964, Neogene Moll. Northwest. Ecuador, pl. 20, figs. 5, 5a (not in text).

Trophon actinophorus Dall. BULLIS, 1964, Tulane Stud. Zoology, v. 11, no. 4, p. 107; RIOS, 1975, Brazilian Marine Moll. Icon., p. 88, pl. 25, fig. 361 (after Dall).

Murex (Paziella) actinophorus (Dall). BAYER, 1971, Bull. Marine Sci., v. 21, no. 1, p. 157, text-figs. 30, 35D (radula).

Actinotrophon actinophorus (Dall). RADWIN and D'ATTILIO, 1976, *Murex* Shells of the World, p. 176, text-fig. 116 (after Dall); D'ATTILIO, 1980, Festivus, v. 12, no. 4, p. 61, fig. 1.

Poirieria actinophorus (Dall). RIOS, 1985, Seashells of Brazil, p. 83, pl. 29, fig. 361 (after Dall).

Holotype: Harvard Mus. Comp. Zool. 7313; height 17.5 mm, diameter (including spines) 14.0 mm.

Type locality: "Blake" Station 143, off Santa Cruz (St. Croix, V.I.), in 248 fms [453.5 m].

Occurrence: Esmeraldas beds, Ecuador. Recent, western Atlantic from Bahama Islands to Brazil, Panama and Colombia (fide Bayer, 1971, p. 159).

Figured specimens: Fig. 3, USNM 430478; height 20.6 mm, diameter (including spines) 14.3 mm; locality, Virgin Islands, Recent. Fig. 4, USNM 418047; height 18.2 mm, diameter 8.7 mm; locality TU 1397. Fig. 5, USNM 418048; height 17.5 mm, diameter 9.3 mm; locality TU 1397.

Discussion: In his study of the Esmeraldas fauna, Olsson included two figures of a poorly-preserved specimen he identified only as "Unnamed," including it among the Turridae. Our collections added another two, somewhat better, specimens and it is obvious that the species is not a turrid but a peculiar muricid, living today in the deep waters (averaging 440 m, Bayer, 1971, p. 159) of the Caribbean Sea.

Originally described as a *Trophon*, the species has been so considered until 1971, when Bayer studied the radula and observed that it was identical to that of *Poirieria (Paziella)*. Conchologically the shell differs from *Paziella* in having an open outer lip and no spines encircling the siphonal canal, exactly the features that separate *Paziella* from *Poirieria* s.s.

Although the appearance of a species of *Poiriera* in the Esmeraldas is of great interest, it is not too significant. The genus *Poirieria* appears first in the Paleocene of Alabama (Vokes, 1971, p. 37), occurs in the Lower Eocene of England, and the Middle Eocene of New Zealand (Maxwell, 1971, p. 764). The living species that is type of the genus, *Murex zelandicus*, differs little from the Eocene forms and obviously this is an extremely conservative group that has survived with little change in deeper waters. Indeed, the Caribbean *P. actinophora* is virtually identical to the New Zealand *P. delli* Maxwell (1971, p. 771, figs. 1, 28-30), from the Lower Miocene, a species that

---

PLATE 5

Figures — Page

1, 2. *Pteropurpura (Ocinebrellus) ecuadoria* (Olsson) 41
1. (X 1 1/2) USNM 418052; height (incomplete) 36.3 mm, diameter 28.0 mm.
2. (X 3) USNM 418053; height 18.4 mm, diameter 9.6 mm.
Locality of both: TU 1397; Esmeraldas beds, Ecuador.

3. *Pteropurpura (Ocinebrellus) acanthophora* (A. Adams) 41
(X 1 1/2) BMNH (holotype); height 38.7 mm, diameter 24.3 mm.
Locality: Tsusaki, Japan, 37 fms (68 m); Recent.

4. *Pteropurpura (Pteropurpura) trialata* (Sowerby) 41
(X 1 1/2) USNM 859925; height 41.6 mm, diameter 22.0 mm.
Locality: Southern California; Recent.

5. *Pteropurpura (Pteropurpura) marksi* Olsson 41
(X 1 1/2) USNM 418054; height 38.0 mm, diameter 25.5 mm.
Locality: TU 1397; Esmeraldas beds, Ecuador.

6, 7. *Ceratostoma notiale* E. H. Vokes, n. sp. 40
6. (X 2 1/2) USNM 418055 (holotype); height 19.5 mm, diameter 11.0 mm.
7. (X 2) USNM 418056 (paratype); height (incomplete) 22.5 mm, diameter (incomplete) 11.0 mm.
Locality of both: TU 1399; Esmeraldas beds, Ecuador.

8. *Ceratostoma nuttalli* (Conrad) 40
(X 2 1/2) USNM 859928; height 19.1 mm, diameter 10.3 mm.
Locality: Baja California, Mexico, *ca.* 160 km (100 miles) south of San Diego, California; Recent.

PLATE 5

Maxwell considers to be most closely related to the Recent *P. kopua* Dell, 1956, found in the deeper waters off New Zealand (600-700 m *ex* Dell, 1963, *in* Maxwell, 1971, p. 764).

Thus, *P. actinophora* is one of a group of Tethyan relics that survives throughout the world. Its presence in the Esmeraldas fauna is of interest primarily from the aspect that the group, so far as is known, no longer occurs in the eastern Pacific fauna, making it one of the few "caribphiles" as named by Woodring (1966, p. 430), who observed that the percent of caribphiles is much lower than paciphiles.

Considering the habitat of the Recent examples of *P. actinophora,* it is obvious that the Esmeraldas specimens lived at a similar depth when overwhelmed by the influx of shallower material.

Subgenus PAZIELLA Jousseaume, 1880

Paziella JOUSSEAUME, 1880, Le Naturaliste, Année 2, no. 42, p. 335.

Type species: *Murex pazi* Crosse, 1869, by original desig.

Bathymurex CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 41.

Type species: *Murex (Bathymurex) atlantis* Clench and Pérez Farfante, 1945, by original desig.

POIRIERIA (PAZIELLA) MERIDIONALIS (Olsson)
Plate 4, figs. 1, 2

Boreotrophon meridionalis OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 140, pl. 26, figs. 5, 5a.

Holotype: USNM 644138; height 32.2 mm, diameter 19.3 mm.

Type locality: Esmeraldas beds; Punta Gorda, Ecuador.

Occurrence: Esmeraldas beds, Ecuador.

Figured specimens: Fig. 1, USNM 418045; height 27.4 mm, diameter 15.5 mm. Fig. 2, USNM 418046; height 12.0 mm, diameter 7.9 mm. Locality of both: TU 1397.

Discussion: The species that Olsson referred to *Boreotrophon* is not of that group, but it is a deep-water form, nonetheless. In the Galápagos Islands, there is a living species named as "*Murex*" *galapaganus* by Emerson and D'Attilio (1970, p. 271, pl. 39, figs. 3-6), which is extremely close to *P. meridionalis,* so close that it can be no more than a subspecies at best. The only discernable difference is an extra spiral cord, with a resulting spinelet on each varix, seen in the younger form. This latter species occurs in depths of 150-200 meters, suggesting a similar environment for *P. meridionalis.*

The generic assignment for "*M.*" *galapaganus,* and by extension "*B.*" *meridionalis,* was discussed by the original authors, who noted that in shell morphology it is closest to *Bathymurex* and *Paziella,* but the heavy chalky intritacalx is most like *Takia* Kuroda, 1953, which, however, lacks the spinose varices. The operculum and radula they felt were closest to two Japanese species, "*Boreotrophon*" *gorgon* Dall, 1913, and "*B.*" *echinus* Dall, 1918. The latter subsequently have been placed in the genus *Nipponotrophon* Kuroda and Habe, 1971; thus, Radwin and D'Attilio (1976, p. 83) transferred "*M.*" *galapaganus* to *Nipponotrophon.*

Nipponotrophon is superficially similar to *Paziella* in shell morphology but has a radula almost identical to that of *Boreotrophon* (*cf.* Radwin and D'Attilio, 1976, text-figs. 48 and 121). However, "*M.*" *galapaganus* has a radula (see Emerson and D'Attilio, 1970, text-fig. 3) most like that of *Poirieria zelandica* (see Radwin and D'Attilio, 1976, text-fig. 57). The operculum (Emerson and D'Attilio, 1970, text-fig. 4) is not like any of the aforementioned genera, having a sublateral nucleus. But the operculum is not as critical a criterion as the radula, given the variation seen within other muricine genera (*e.g.*, *Murex* s.s.).

The only known species of *Nipponotrophon* are those from the western Pacific, whereas *Paziella* is now found only in the New World, although it was worldwide in earlier geologic times. The eastern Pacific forms are most like three species in the Caribbean that would be assigned to *Bathymurex* Clench and Pérez Farfante, 1945, if that taxon were considered to be sufficiently distinct from *Paziella* to be recognized. These include two fossil species: *P. dominicensis* (Gabb, 1873), occuring in the Early Pliocene Gurabo Formation of the Dominican Republic and the mid-Pliocene Concepcion Inferior Formation of Mexico, and *P. septima* Vokes, 1970, from the same Concepcion Inferior; and the Recent "*Murex*" *atlantis,* type of *Bathymur-*

ex. These three species differ from typical *Paziella* in lacking the spines encircling the base of the shell, and differ from the eastern Pacific species in that the spiral cords are more pronounced in the intervarical area but do not produce spinelets at the varices, except on the shoulder.

In *P. dominicensis* many of the specimens seem to have an outer organic layer that causes pyrite deposition on the shell; all of the Ecuadorian specimens are badly decorticated; and there is but one dead-taken specimen known of *P. atlantis*. Thus, it is possible that the heavy intritacalx of *P. galapagana* is characteristic of the group. If more examples of *P. atlantis* should demonstrate this, then the taxon *Bathymurex* could be redefined for those few species of *Paziella* lacking the spines on the canal and having the heavy intritacalx. For the present, they will be assigned to *Paziella*.

It should be noted that "*Nipponotrophon galapaganus*" from the Gulf of California, reported by Skoglund (1983, p. 107, figs. 3,4) is obviously not that species, as the specimen, among other differences, has very strong spines on the siphonal canal. Her shell is probably a new species of *Muricopsis*.

Poirieria (Paziella) atlantis is another deep-water form, the holotype coming from about 350 meters, off Cuba (Clench and Pérez Farante, 1945, p. 41). Examples of *P. dominicensis* are from beds that, on the basis of the other fauna, are assumed to be of comparable depth. As *P. meridionalis* is one of the few muricid species relatively common in the Esmeraldas beds (24 specimens from TU 1397; one from TU 1399), it is probable that it too was a member of the deeper Esmeraldas fauna.

Genus ATTILIOSA Emerson, 1968

Attiliosa EMERSON, 1968, Veliger, v. 10, p. 380.

Type species: *Coralliophila incompta* Berry, 1960, by original desig. (*C. incompta* Berry = *Peristernia nodulosa* A. Adams, 1855).

ATTILIOSA NODULOSA (Adams)
Plate 6, figs. 5, 6

Peristernia nodulosa A. ADAMS, 1855, Zool. Soc. London, Proc., (1854), p. 313; HEDLEY, 1908, Linnean Soc. New South Wales, Proc., v. 33, p. 486, pl. 8, fig. 11 (syntype).

Coralliophila nodulosa (Adams). MELVILL, 1891, Manchester Lit. Phil. Soc., Proc., (Ser. 4) v. 4, pp. 409, 410.

Coralliophila incompta BERRY, 1960, Leaflets in Malac., v. 1, no. 19, p. 119; DUSHANE and POORMAN, 1967, Veliger, v. 9, p. 429; DUSHANE and SPHON, 1968, Veliger, v. 10, p. 242, pl. 35, fig. 11.

Attiliosa incompta (Berry). EMERSON, 1968, Veliger, v. 10, p. 380, pl. 53, figs. 1 (holotype), 2-5; text-figs. 2-3 (radula), 4, 5 (operculum); KEEN, 1971, Sea Shells Trop. West Amer., ed. 2, p. 529, fig. 1021; RADWIN and D'ATTILIO, 1976, *Murex* Shells of the World, p. 26, pl. 3, fig. 1, text-fig. 10 (radula).

Attiliosa nodulosa (Adams). BULLOCK, 1976, Tulane Stud. Geol. Paleont., v. 12, no. 3, p. 133, pl. 1, figs. 6-8 (syntypes); RADWIN and D'ATTILIO, 1978, Tulane Stud. Geol. Paleont., v. 14, no. 3, p. 32, figs. 5, 5a (radula); VOKES and D'ATTILIO, 1982, Veliger, v. 25, p. 69; VOKES, 1984, Shells and Sea Life, v. 16, no. 11, p. 212, pl. 1, fig. 21.

Holotype: Stanford University Paleo. Type Coll. 9512; now CAS 043915; height 33.5 mm, diameter 20.3 mm.

Type locality: Isla Angel de la Guarda, Baja California.

Occurrence: Esmeraldas beds, Ecuador. Recent, Baja California to Panama (*fide* Keen, 1971, p. 530).

Figured specimens: Fig. 5, USNM 859927; height 31.5 mm, diameter 19.0 mm; locality, off Guaymas, Sonora, Mexico, Recent. Fig. 6, USNM 418059; height 25.7 mm, diameter 16.6 mm; locality TU 1399.

Discussion: Keen (1971, p. 530) states that this species occurs as far south as Panama, in depths of 18-80 meters; however, according to Emerson (1968, p. 380), most material has been taken in about 30 meters. Thus, this single specimen from TU 1399 is another member of the shallow-water fauna that predominates at that locality.

Subfamily MURICOPSINAE
Radwin and D'Attilio, 1971

Genus MURICOPSIS
Bucquoy and Dautzenberg, 1882

Muricopsis BUCQUOY and DAUTZENBERG *in* BUCQUOY, DAUTZENBERG and DOLLFUS, 1882, Moll. Mar. Roussillon, v. 1, p. 19.

Type species: *Murex blainvillei* Payraudeau, 1826, by original desig.

MURICOPSIS OXYTATA (Smith)
Plate 4, figs. 9, 10

Murex hexagonus LAMARCK, 1816, Tableau Encycl. Meth. (Vers), v. 3, pl. 418, fig. 3; LAMARCK, 1822, Anim. s. Vert., v. 7, p. 169; KIENER, 1843, Coq. Viv., v. 7, *Murex*, p. 96, pl. 8, fig. 3; REEVE, 1845, Conch. Icon., v. 3, *Murex*, pl. 27, fig. 120; SOWERBY, 1879, Thes. Conch., v. 4, *Murex*, fig. 257 (*non M. hexagonus* Gmelin, 1791).

Murex hexagonus oxytata M. SMITH, 1938, Nautilus, v. 51, p. 89, pl. 6, fig. 6.

Muricopsis hexagonus (Lamarck). OLSSON and HARBISON, 1953, Acad. Nat. Sci. Phila., Mon. 8, p. 247, pl. 37, fig. 4 (including *M. hexagonus oxytata* in synonymy); ABBOTT, 1954, Amer. Seashells, ed. 1, p. 209, pl. 25h.

Muricidea hexagonus (Lamarck). M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 11, pl. 6, fig. 3.

Muricopsis oxytata/oxytatus (Smith). ABBOTT, 1958, Acad. Nat. Sci. Phila., Mon. 11, p. 63; WARMKE and ABBOTT, 1961, Caribbean Sea Shells, p. 106, pl. 19e; ABBOTT, 1974, Amer. Seashells, ed. 2, p. 197, fig. 1957; HUMFREY, 1975, Sea Shells of the West Indies, p. 137, pl. 16, figs. 2, 2a; FAIR, 1976, *Murex* Book, p. 64, pl. 17, fig. 226; RADWIN and D'ATTILIO, 1976, *Murex* Shells of the World, p. 169, pl. 27, fig. 5; VOKES, 1984, Shells and Sea Life, v. 16, no. 11, p. 214, back cover color photo.

Muricopsis lyonsi PETUCH, 1986, Jour. Coastal Resh., v. 2, no. 4, p. 404, pl. 4, figs. 12, 13.

Holotype: Not found; height 22 mm (*fide* Smith, 1938).

Type locality: Caloosahatchee Formation; Clewiston, Hendry County, Florida.

Occurrence: Esmeraldas beds, Ecuador. Tubará Group, Colombia; Pliocene. Pinecrest beds, Caloosahatchee and Bermont formations, Florida; Plio-Pleistocene. Moín Formation, Costa Rica; Pleistocene. Recent, western Atlantic, Florida to northern South America, Panama and Costa Rica.

Figured specimens: Fig. 9, NMB H 17338; height 28.0 mm, diameter 14.7 mm; locality, K-493, Trans-Ecuadorian Pipeline. Fig. 10, USNM 418051; height 19.3 mm, diameter 9.0 mm; locality TU 726.

Discussion: As the name *Murex hexagonus* of Lamarck is preoccupied by that of Gmelin, 1791, the next available name for the species is *M. oxytata* for, although Smith distinguished the Florida form as a subspecies, the distinction is not valid (Abbott, 1958, p. 63). The spelling "*oxytatus*" is used by many authors, thinking the ending should agree with the generic taxon; however, "*oxytata*" is a noun, meaning "spiny daddy," evidently in reference to what Smith assumed was its ancestral relationship to the Recent "*M. hexagonus*."

PLATE 6

Figures — Page

1, 2. *Typhis (Talityphis) latipennis* Dall 44
1. (X 2) USNM 418057; height 27.0 mm, diameter 20.4 mm.
Locality: TU 1397; Esmeraldas beds, Ecuador.
2. (X 2) USNM 859926; height 32.5 mm, diameter 19.0 mm.
Locality: El Dorado, Jalisco, Mexico, 28 fms (51 m); Recent.

3, 4. *Typhis (Talityphis) alatus* Sowerby 46
3. (X 2) USNM 418058; height 26.7 mm, diameter (incomplete) 13.2 mm.
Locality: TU 1399; Esmeraldas beds, Ecuador.
4. (X 2) USNM 323910; height 27.7 mm, diameter 17.2 mm.
Locality: TU 1212; Gurabo Fm., Dominican Republic.

5, 6. *Attiliosa nodulosa* (A. Adams) 33
5. (X 1 1/4) USNM 859927; height 31.5 mm, diameter 19.0 mm.
Locality: Off Guaymas, Sonora, Mexico; Recent.
6. (X 1 1/2) USNM 418059; height 25.7 mm, diameter 16.6 mm.
Locality: TU 1399; Esmeraldas beds, Ecuador.

7-9. *Vitularia salebrosa* (King and Broderip) 42
7. (X 1) PRI 20481 (holotype - *V. ecuadorana* Marks); height 59.1 mm, diameter 30.5 mm.
Locality: Daule Basin; Daule Fm., Ecuador.
8. (X 2) USNM 418060; height 20.9 mm, diameter 13.8 mm.
9. (X 2) USNM 418061; height 19.1 mm, diameter 10.6 mm.
Locality of both: TU 1399; Esmeraldas beds, Ecuador.

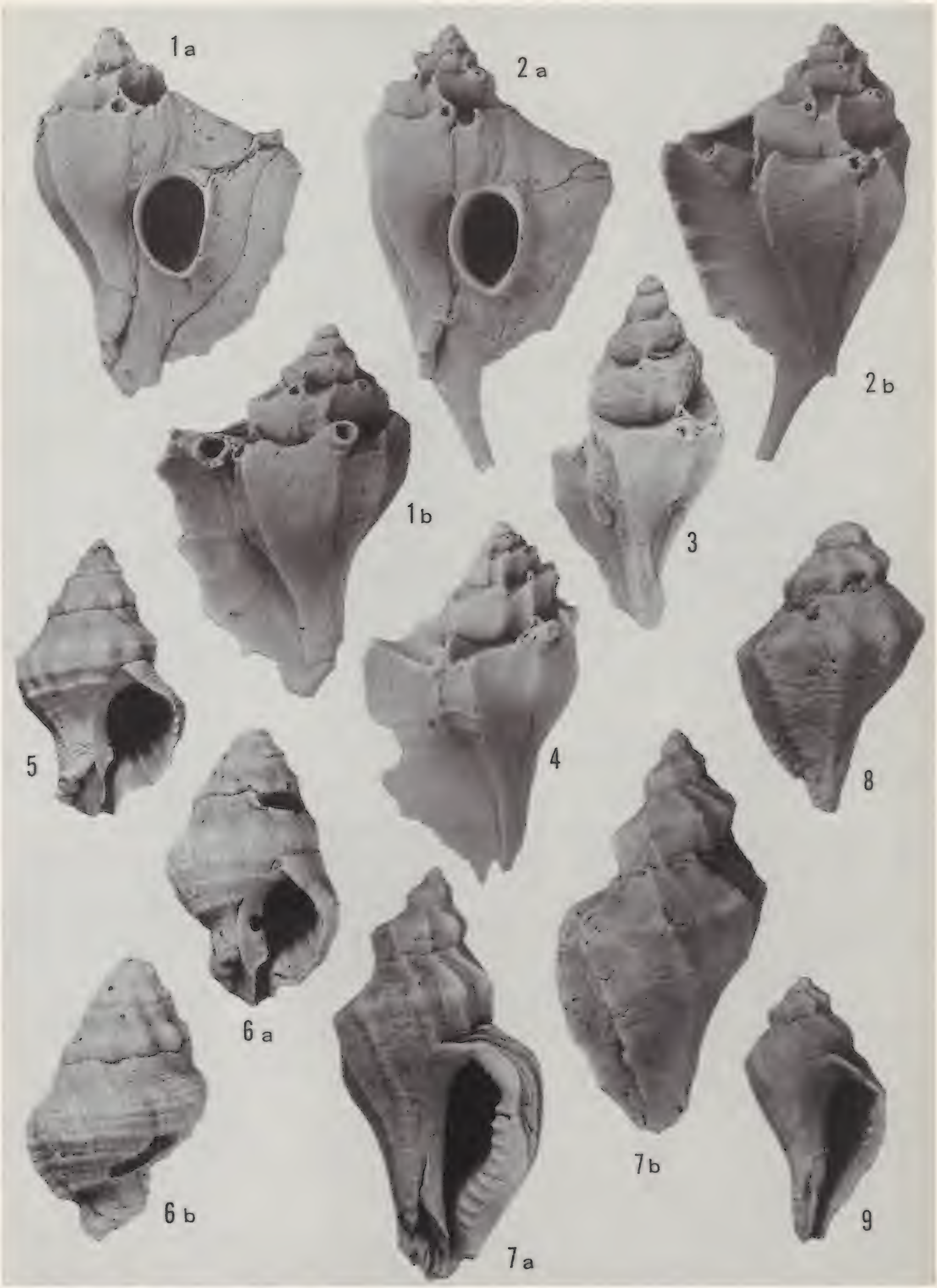


PLATE 6

This is a widespread species in both the fossil and Recent record of the western Atlantic. In addition to the many localitites in the Plio-Pleistocene of southern Florida, we also have several examples from both the Pleistocene Moín Formation and the Recent of Costa Rica, and in the collections of the Museum of Paleontology, University of California, Berkeley, there is a single example from the mid-Pliocene Tubará Group, at Punta Pua, Dept. of Bolivar, Colombia. Undoubtedly, the reason it is absent in the Gatun Formation is that it is almost totally confined to coralline facies. In the Recent fauna of the eastern Pacific the cognate species is *M. armatus* (Adams, 1854), which may be distinguished by having the varices irregularly aligned up the spire in contrast to the perfect hexagonal alignment of *M. oxytata*. Although Keen (1971, p. 523) indicated the species is confined to the Gulf of California, we have examples from Isla Gobernador, Panama. But everywhere, it occurs under stones at low tide; evidently upon moving into the non-coralline eastern Pacific the ancestral form was forced to make an adjustment in habitat.

In an Ecuadorian collection made by Peter Jung, of the Naturhistorisches Museum, Basel, Switzerland, there is a single specimen of what proves to be *M. oxytata*, not *M. armatus*. His locality is not the same as ours, being at K-493 on the Trans-Ecuadorian Pipeline, or about 10 km south of Esmeraldas (near the road to the bridge over the Rio Esmeraldas); however, the associated fauna indicates that the outcrop is identical to that at Camarones.

A new species, *M. lyonsi*, was described by Petuch (1986, p. 404, pl. 4, figs. 12, 13) from the mid-Pliocene of the Miami area, which he stated differs from *M. oxytata* in lacking the varical spines, having instead large varical scales. In our collections, we have a number of these short-spined forms from several localities, both correlative with the type material (TU 541, 1000) and younger (TU 202-Caloosahatchee Fm.; TU 1240-Moín Fm.). Examination of topotypic material (TU 1493) suggests that the differences are only ecological – perhaps rougher water.

Genus MUREXSUL Iredale, 1915

Murexsul IREDALE, 1915, New Zealand Inst., Trans., Proc., v. 47, p. 471.

Type species: *Murex octogonus* Quoy and Gaimard, 1833, by original desig.

Discussion: The genus *Murexsul* is one of the original muricid genera, going back to the Eocene when it was distributed worldwide. At the time the writer originally discussed ths genus (Vokes, 1968, pp. 87, 106), she considered it a subgenus of *Hexaplex*. But additional work on the history of the Muricidae (Vokes, 1971) and work on the nature of the radula, which resulted in Radwin and D'Attilio (1971) separating those forms with a three-dimensional rachidian tooth into a subfamily Muricopsinae, shows that this assignment was incorrect. However, the shell morphology in many cases remains discouragingly similar and the early fossil species, such as the *Hexaplex engonatus* (Conrad) complex, may well be members of *Murexsul*. But, in general, the two may be separated by the presence of an anal notch in *Hexaplex*, not seen in *Murexsul*, and the fact that the shoulder spine is usually longer than the other spines in *Hexaplex* but they are all of about the same length in *Murexsul*.

Ponder (1972, p. 237) took issue with Vokes's statement (1964, p. 19) that *Murexsul* might be separated from the similar *Muricopsis*, "by the extreme development of the denticles on the outer lip," stating that he felt this was not a valid distinction. However, as the two groups have been separate since the Eocene (there is a good Eocene species of *Muricopsis* in California – *Muricopsis vistanensis* Givens and Kennedy, 1976), plus the presence of the denticles on the *inner* lip of *Muricopsis* and its subgenus *Risomurex* Olsson and McGinty, 1958 (see Vokes and Houart, 1986), little is gained by combining the two groups. Nevertheless, Ponder is correct in observing that the two are very closely related.

The genus *Murexsul*, has not previously been recognized in the living western Atlantic fauna, until Petuch (1987, p. 100, pl. 21, figs. 11, 12) described *Murexsul harasewychi* from 35 meters depth off the coast of Colombia. In addition, the Brazilian *Muricopsis oxossi* Petuch, 1979, is ex-

tremely like the Mediterranean *Murexsul aradasii* (Monterosato *in* Poirier, 1881; a synonym of *Murex medicago* Watson, 1897; see Fair, 1976, p. 21, pl. 17, fig. 244 - type of *medicago*), and both are better placed in *Murexsul* than in *Muricopsis*.

In the Pleistocene Moín Formation of Costa Rica and the Late Pliocene Waccamaw Formation of South Carolina there are undescribed species of *Murexsul*, in addition to the mid-Pliocene *M. thalmanni* (Vokes, 1968) from the Agueguexquite Formation of Mexico. In the eastern Pacific, there is the Galapagan *M. jacquelinae* Emerson and D'Attilio, 1969, and the recently recognized *"Murex" dipsacus* Broderip, 1833 (see Vokes, 1984, note 8). So, the presence of *Murexsul* in the Esmeraldas beds is not unexpected. What is a bit disappointing is that it is not the same species as is found in the Mexican Pliocene.

MUREXSUL PITTI E. H. Vokes, n. sp.
Plate 4, fig. 6

Description: Shell large for the New World members of the group, attaining a height of 30 mm; early whorls unknown, as is total number, but probably seven adult whorls. On earliest whorls preserved, spiral ornamentation consisting of two weak cords, best seen as spines where the varices are crossed, that at the shoulder stronger; a weak thread between the pair. On body whorl, three major spiral cords, each drawn out into spines at the varices; alternating with weaker cords, also making shorter spines where they cross the varices, each of these flanked by even smaller spinelets. One strong cord on siphonal canal, also drawn into spines at varices. Axial ornamentation of seven low varices on each whorl present; these visible principally where the spiral cords are developed into spines. The adapertural faces of the varices formed by multiple layers of shell material, each folded into the inner side of the open spines. Area between varices almost smooth, unworn examples probably covered with a shagreened surface. Aperture circular, no anal notch; inner lip free-standing, smooth; outer lip crenulated at outer margin into the varical spines, with about eight small nodules on inner side. Siphonal canal deflected at the distal end, forming a small umbilical chink.

Holotype: USNM 418049; height 30.0 mm, diameter 19.5 mm. (Plate 4, fig. 6)

Type locality: TU 1397, Esmeraldas beds; Quebrada Camarones, cut-bank on east side of canyon, which is at east side of the village of Camarones, 20 km (by road) east of bridge over Rio Esmeraldas, Prov. of Esmeraldas, Ecuador.

Occurrence: Esmeraldas beds, Ecuador.

Discussion: This new species, named for William D. Pitt, our co-worker in Ecuador, is represented by two battered specimens from Quebrada Camarones. It is most similar to *M. thalmanni* (Vokes, 1968), from the mid-Pliocene Agueguexquite Formation of Veracruz, Mexico, but differs by its much larger size – none of the dozen specimens we have from Mexico measures more than 16 mm in height. The surface in the latter is also more scabrous, with both major and minor spiral cords being well developed in the intervarical spaces.

Unfortunately, for paleo-depth indications, this new species is not closely related to any of the extant members of the genus. But most species occur in moderate depths (*M. octogonus*, the type species, 18-64 m; *jacquelinae*, 30-100 m; *aradasii*, 30-50 m; *medicago*, 91 m [50 fms]; *oxossi*, 25 m; *dipsacus*, 23 m [12 fms]) so we may assume that the Esmeraldas species did the same. Likewise, its presence does not help our understanding of the origins of the Esmeraldas fauna, as the genus is another Tethyan relic with worldwide distribution for most of the Cenozoic.

Genus MUREXIELLA
Clench and Pérez Farfante, 1945

Murexiella CLENCH and PÉREZ FARFANTE, 1945, Johnsonia, v. 1, no. 17, p. 49.

Type species: *Murex hidalgoi* Crosse, 1869, by original desig.

MUREXIELLA LAPPA (Broderip)
Plate 4, figs. 7, 8

Murex lappa BRODERIP, 1833, Zool. Soc. London, Proc., v. 2, p. 177; SOWERBY, 1834, Conch. Illus., *Murex*, pl. 60, fig. 15; REEVE, 1845, Conch. Icon., v. 3, *Murex*, pl. 30, fig. 142; SOWERBY, 1879, Thes. Conch., v. 4, *Murex*, fig. 238.

Murex (Phyllonotus) lappa (Broderip). M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 13, pl. 13, fig. 7.

Ocenebra lappa (Broderip). KEEN, 1958, Sea Shells Trop. West Amer., ed. 1, p. 359, fig. 356.

Murexiella lappa (Broderip). VOKES, 1970, Veliger, v. 12, p. 325; KEEN, 1971, Sea Shells Trop. West Amer., ed. 2, p. 519, fig. 990; FAIR, 1976, *Murex* Book, p. 53, pl. 19, fig. 269; RADWIN and D'ATTILIO, 1976, *Murex* Shells of the World; p. 158, pl. 26, fig. 5;

VOKES, 1984, Shells and Sea Life, p. 212, pl. 2, fig. 7.

Lectotype (here designated): BMNH 1964439/1 (specimen figured by Sowerby, 1834, fig. 15); height 30.1 mm, diameter (including spines) 20.7 mm.

Type locality: Bahía de Sta. Elena, Ecuador.

Occurrence: Esmeraldas beds, Ecuador. Charco Azul Formation, Pleistocene; Panama. Recent, Gulf of California to Peru.

Figured specimens: Fig. 7, USNM 859924; height 14.7 mm, diameter 9.0 mm; locality TU R-166. Fig. 8, USNM 418050; height 13.7 mm, diameter 8.0 mm; locality TU 1397.

Discussion: In an earlier study of the west coast members of *Murexiella,* Vokes (1970, p. 327) suggested that several of the nominal species might be synonyms of *M. lappa.* But a subsequent visit to the British Museum (Nat. Hist.) disclosed that the type specimens of the various species are now being recognized in the collections with the result that *none* of the species originally listed as "probable" synonyms really is so. The type of *"Murex" dipsacus* Broderip, 1833, proves to be a *Murexsul* (see note 8 in Vokes, 1984, p. 215; pl.2, fig. 25 is the type specimen). *"Murex" exiguus* Broderip, 1833, is a valid species (type figured in Vokes, 1984, pl. 2, fig. 3) and *"Murex" radicatus* Hinds, 1844, is a synonym of it, with both being characterized by flattened spiral cords.

However, *M. lappa* may still be the "ancestor" of the lot, as the species that occurs in the Esmeraldas is *M. lappa,* and the three and one-half whorl protoconch indicates that this is the primitive form, with the widest geographical distribution. It lives from intertidally under stones (Panama, Vokes Coll.) to 37 m (Keen, 1971, p. 519). The three specimens taken at TU 1397 are undoubtedly transported elements of the fauna.

Genus ACANTHOTROPHON Hertlein and Strong, 1951

Acanthotrophon HERTLEIN and STRONG, 1951, Zoologica, v. 36 (East. Pacific Exped. New York Zool. Soc., XLIII. Moll. West Coast Mexico and Central Amer., Part X), p. 86.

Type species: *Trophon (Acanthotrophon) sorenseni* Hertlein and Strong, 1951, by original desig.

ACANTHOTROPHON SORENSENI (Hertlein and Strong)

Plate 3, figs. 6, 7

Trophon (Acanthotrophon) sorenseni HERTLEIN and STRONG, 1951, Zoologica, v. 36 (East. Pacific Exped. New York Zool. Soc., XLIII. Moll. West Coast Mexico and Central Amer., Part X), p. 86, pl. 2, fig. 1; KEEN, 1958, Sea Shells Trop. West Amer., ed. 1, p. 364, fig. 371 (holotype); KEEN, 1971, *ibid.*, ed. 2, p. 537, fig. 1043 (holotype).

Acanthotrophon sorenseni (Hertlein and Strong). RADWIN and D'ATTILIO, 1976, *Murex* Shells of the World, p. 20, text-fig. 2 (holotype); RADWIN and D'ATTILIO, 1978, Tulane Stud. Geol. Paleont., v. 14, no. 3, p. 132; VOKES, 1980, Veliger, v. 23, p. 11, figs. 13, 14 (holotype), 15 (protoconch).

Acanthotrophon sentus Berry. RADWIN and D'ATTILIO, 1978, Tulane Stud. Geol. Paleont., v. 14, no. 3, in part, figs. 3, 3a only (*not* of Berry).

Holotype: CAS 9611; height 32.2 mm, diameter 20.0 mm.

Type locality: Gorda Banks, off Cabo San Lucas, Baja California Sur, Mexico.

Occurrence: Esmeraldas beds, Ecuador. Recent, Gulf of California.

Figured specimens: Fig. 6, USNM 418044; height 27.7 mm, diameter 18.1 mm; locality TU 1399. Fig. 7, CAS 9611 (holotype).

Discussion: Radwin and D'Attilio (1978, p. 132) have demonstrated that the species referred to the genus *Acanthotrophon* are not to be placed in the Trophoninae, but are members of the subfamily Muricopsinae. The type species, *A. sorenseni,* is the least muricopsine-appearing of the group, but other species, such as *A. carduus* (Broderip, 1833), have a much more scabrous, "typical" muricopsine shell.

There is another species of "Trophoninae" that is probably also to be referred to this genus. This is *Austrotrophon panamensis* Olsson (1971, p. 68, figs. 36, 37), described from 84 meters in the Bay of Panama. Although Olsson compared his new species to *Austrotrophon cerrosensis* (Dall, 1891), type of that genus, the Panamian shell lacks the varical flanges extended along the entire length of the siphonal canal, having instead only open spines at the shoulder. This is the only obvious conchological feature that seems to distinguish *Austrotrophon* from *Acanthotrophon.* But the two are readily separable by the radula (thaidine in *Au-*

strotrophon, muricopsine in *Acanthotrophon*) and the operculum (purpuroid in *Austrotrophon,* muricoid in *Acanthotrophon*). Unfortunately, the sole example of *A. panamensis* was not taken live and we are not sure of the proper placement for the species. But comparison of the shells (see pl. 3, figs. 7 and 8) seems to indicate that *A. panamensis* is closely akin to *A. sorenseni*. The difference is only in the degree of strength of the spiral cords on the body whorl. However, *A. sorenseni* is variable in this feature (see the two specimens illustrated in a previous paper on the subject – Vokes, 1980, figs. 13,14). The type of *A. panamensis* also lacks lirations within the outer lip but these are often lacking in specimens of *A. sorenseni* and are always only weakly developed (Vokes, 1980, p. 11).

Therefore, although not positive it is probable that *A. panamensis* is to be referred to *Acanthotrophon;* what is more, the form may be a synonym of the more northern *A. sorenseni,* but we lack comparative material to verify this. If the type specimen of *A. panamensis* had been taken in the Gulf of California it probably would have been referred to the latter species.

This possibility is supported by the discovery of a single specimen in the Esmeraldas beds that must be referred to *A. sorenseni*. As several other species found in the Esmeraldas beds today occur from the Gulf of California to Panama, the possibility that *A. sorenseni* also ranges this far exists and the probability that *A. panamensis* is a synonym is plausible.

The type specimen of *A. sorenseni* was taken in 109 m; the type of *A. panamensis* in 84 m. Other material of *A. sorenseni* was reported by Vokes (1980, p. 14) from 36 to 100 m. Thus, this is another of the moderately deep-water elements in the Esmeraldas fauna.

Subfamily THAIDINAE Jousseaume, 1888

Discussion: In a work on the muricid fauna of the Mio-Pliocene of the Dominican Republic, Vokes (in press) presents the arguments for and against recognition of a separate family Thaididae, in contrast to placement as a subfamily within the Muricidae, and concludes that the latter course is preferable. Therefore, the subfamily Thaidinae is defined as those muricid species that have a calcitic shell, a purpuroid operculum, and a pentacuspidate rachidian radular tooth. By this definition, there is no distinction by which the subfamily Ocenebrinae may be recognized, as it is identical except for the presence of varices, which can be demonstrated to be meaningless, and it is here synonymized with the subfamily Thaidinae.

Genus CERATOSTOMA Herrmannsen, 1846

Cerostoma CONRAD, 1837, Acad. Nat. Sci. Phila., Jour., v. 7, p. 263.

Type species: *Murex (Cerostoma) nuttalli* Conrad, 1837, by monotypy.

Ceratostoma HERRMANNSEN, 1846, Indicis Generum Malakoz., v. 1, p. 206. New name for *Cerostoma* Conrad, 1837, *non* Latreille, 1802.

Discussion: When the writer originally (Vokes, 1964) presented a revision of the supraspecific groups of what was then the Muricidae and "Tritonaliinae" (now Ocenebrinae, ICZN Opinion 886, 1969) she placed all of the ocenebrine genera with a labral tooth (or ceratus) in the genus *Jaton* Pusch, 1837, with *Ceratostoma* and *Pterorytis* Conrad, 1863, as subgenera. But this is certainly an artificial grouping, as the labral tooth appears repeatedly in various muricid taxa and its presence clearly does not imply close relationship. Thus, it seems now that *Jaton* is a *Pteropurpura* with a tooth; *Pterorytis* is an *Ocinebrellus* with a tooth; and *Ceratostoma* is an *Ocenebra* with a tooth.

Unfortunately, because of the Law of Priority, in every case mentioned above, the toothed form is an earlier name. Therefore, one has the choice of making these well-known junior taxa subgenera of the older named taxa, or accepting all as valid genera. The latter course will be followed here.

In the case of *Ceratostoma* and *Ocenebra* there are other substantive differences, including the usually three (*C. rorifluum* has four), usually winged (but not always) varices, and especially the presence of strong denticles on the inner side of the outer lip in *Ceratostoma,* which are not present in

Ocenebra. The shell in *Ceratostoma* is also much less scabrous than in *Ocenebra*.

CERATOSTOMA NOTIALE E.H. Vokes, n. sp.
Plate 5, figs. 6, 7

Description: Shell of average size, probably five teleoconch whorls in adult and a protoconch of two and one-half large whorls (diameter 1.5 mm). Spiral ornamentation on the first postnuclear whorl of two strong cords, gradually weakening until by third or fourth whorl only faint grooves demarcating the former cords, about a dozen on immature specimens, but adult shell almost completely smooth. Axial ornamentation on first teleoconch whorl of about ten equal ribs, these diminishing in number on each successive whorl and developing into rounded varices, with four on the body whorl of the adult. Varices on mature whorls little more than rounded ribs with a small flange at the shoulder, but that at aperture forming a moderately wide, thickened varix, the apertural face consisting of multiple shell laminae, each crenulated into the almost invisible spiral cords. At juncture of body whorl and siphonal canal a narrow, sharp labral tooth, directed adaperturally, with the varix infolded behind it. Aperture ovate, inner lip smooth, free-standing anteriorly, appressed posteriorly, no anal notch. Outer lip crenulated at margin, inner side with seven or eight strong elongate denticles. Siphonal canal of moderate length, sealed over by an extension of shell material from columellar side, distal end recurved. Shell composed of calcite on exterior, with aragonitic cortex, causing the surface to decorticate readily.

Holotype: USNM 418055; height 19.5 mm, diameter 11.0 mm. (Plate 5, fig. 6)

Paratype: USNM 418056; height (incomplete) 22.5 mm, diameter (incomplete) 11.0 mm; locality same as holotype. (Plate 5, fig. 7)

Type locality: TU 1399, Esmeraldas beds; roadcut on west side of village of Camarones, which is 20 km (by road) east of the bridge over Rio Esmeraldas, Prov. of Esmeraldas, Ecuador.

Occurrence: Esmeraldas beds, Ecuador.

Discussion: One of the unusual finds in the Esmeraldas beds is a new species of *Ceratostoma*, most closely related to the common *C. nuttalli* (Conrad), which generally occurs subtidally in the cooler waters of the California Province, extending only as far south as Santa Maria Bay (*fide* McLean, 1978, p. 42), Baja California (the more southerly non-winged form, which extends the range to the southern part of Baja California only, is referred to *C. monoceros* [Sowerby] or *C. unicorne* [Reeve] – see Keen, 1971, p. 534).

Although widespread in the fossil record, with species in the Late Oligocene of North Carolina and the Miocene of Italy, Austria, Mexico, California, and the Far East, by Pleistocene time the group of *Ceratostoma* seems to have constricted its range to the northern Pacific, from Korea and Japan to California. This is the first report of any species in South America – hence the name *notialis*, meaning *southern*.

This new species is most closely related to the California *C. nuttalli* (see pl. 5, fig. 8) but may be distinguished by the (presumably) four varices in the adult (our only adult specimen is incomplete but it seems to have had four varices, as do the immature examples) and by the nature of the protoconch, which in *C. nuttalli* is smaller (about one-half the diameter, or 0.7 mm in *C. nuttalli*) and of only one and one-half almost keeled whorls with much the same appearance as the protoconch of *Ocenebra seftoni* Chace, as figured by Radwin and D'Attilio (1976, text-fig. 74). The protoconch in *C. notiale* is very large for a muricid, and has exactly the appearance of *Phyllonotus pomum* (Gmelin), also as figured by Radwin and D'Attilio (*ibid.*, text-fig. 54).

Except for these differences, the shells are extremely similar and the assumption is made that the two probably lived in similar fashion. All living *Ceratostoma* species tend to occur in shallower water, examples taken from deeper water have conspicuous extended varices. This assessment agrees with the presence of five of the six known specimens of the Ecuadorian form coming from TU 1399, the more shallow-water gravity-flow (see Introduction). One juvenile was found at Quebrada Camarones (TU 1397).

Genus PTEROPURPURA Jousseaume, 1880

Pteropurpura JOUSSEAUME, 1880, Le Naturaliste, Année 2, no. 42, p. 335.

Type species: *Murex macropterus* Deshayes, 1839, by original desig.

Subgenus PTEROPURPURA s.s.

PTEROPURPURA (PTEROPURPURA) MARKSI Olsson

Plate 5, fig. 5

Pteropurpura marksi OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 139, pl. 29, fig. 6.

Holotype: USNM 643955; height 54.3 mm, diameter 37.1 mm.

Type locality: Esmeraldas beds; Punta Gorda, Ecuador.

Occurrence: Esmeraldas beds, Ecuador.

Figured specimen: Fig. 5, USNM 418054; height 38.0 mm, diameter 25.5 mm; locality TU 1397.

Discussion: When Olsson described *Pteropurpura marksi* he compared it only to *Purpurellus pinniger* (Broderip, 1833), which is not even in the same subfamily. Perhaps *Purpurellus pinniger* is the only trialate species that occurs off Ecuador today, but this is scarcely a valid criterion. Certainly *Pteropurpura centrifuga* (Hinds, 1844), which extends as far south as Panama, would be a better choice, the principal difference being the presence in the latter of stronger spiral cords that cause the varices to have three distinct digitations along the margins. But the species that bears the most resemblance to *P. marksi,* indeed from which it scarcely can be separated, is the Californian *P. trialata* (Sowerby, 1834) (cf. pl. 5, figs. 4, 5).

According to Olsson (1964, p. 139), this species was common at Punta Gorda (he had 10 specimens) and it is also at Quebrada Camarones, where we have 20 examples. There are none, however, from the more shallow fauna at TU 1399, suggesting that this is another of the species from a slightly deeper water fauna. In California, the species *P. trialata* is found from intertidally to somewhat offshore (18 m [10 fms], Keep, 1935, p. 235). But its more southern congener *P. centrifuga* is commonly taken by shrimpers in depths of 80-180 m (45-100 fms, DuShane and Poorman, 1976, p. 428). The nearest geographical occurrence to the Ecuadorian coast is *P. deroyana* Berry, 1968, which differs only subspecifically if at all from *P. centrifuga,* described from 46 m (25 fms) in the Galápagos Islands. So, the *Pteropurpura* line probably follows a temperature cline from deeper water off Ecuador to shallower water in California.

Subgenus OCINEBRELLUS Jousseaume, 1880

Ocinebrellus JOUSSEAUME, 1880, Le Naturaliste, Année 2, no. 42, p. 335.

Type species: *Murex eurypteron* Reeve, 1845 (= *M. falcatus* Sowerby, 1834), by original desig.

PTEROPURPURA (OCINEBRELLUS) ECUADORIA (Olsson)

Plate 5, figs. 1, 2

Trophon ecuadorius OLSSON, 1964, Neogene Moll. Northwest Ecuador, p. 140, pl. 29, figs. 7, 7a, 7b.

Holotype: USNM 643958; height 49.0 mm, diameter 33.3 mm.

Type locality: Esmeraldas beds; Punta Gorda, Ecuador.

Occurrence: Esmeraldas beds, Ecuador.

Figured specimens: Fig. 1, USNM 418052; height (incomplete) 36.3 mm, diameter 28.0 mm. Fig. 2, USNM 418053; height 18.4 mm, diameter 9.6 mm; locality of both, TU 1397.

Discussion: Although Olsson named this species as *Trophon* and compared it to *T. lamellosus* (Gmelin, 1791), there is only a superficial resemblance to that group. In the trophons, the varical formation always consists of a single lamina of shell material, overlapped in an adapertural direction. This is true in all of the genera of true Trophoninae, as well as the pseudotrophons, including *Stramonitrophon* Powell, 1951 (of which *lamellosus* is the type, as *M. laciniatus*) and *Austrotrophon* Dall, 1902, which are both thaidines in disguise (see Radwin and D' Attilio, 1976, p. 176), most closely related to *Forreria* Jousseaume, 1880.

The Ecuadorian species shares with the above-mentioned groups a calcitic shell, which decorticates readily, but it also has varices with a thickened apertural face and a closed siphonal canal. The calcitic shell, seven wing-like varices and closed canal indicate placement in the thaidine subgenus *Pteropurpura (Ocinebrellus).* Indeed, the species has a marked resemblance to the Japanese *P. (O.) acanthophora* (A. Adams, 1863) (see the type specimen of the latter: pl. 5, fig. 3). Although this species usually has been placed in the synonymy of "*Murex*" *falcatus* Sowerby, 1834, type of *Ocinebrellus,* *P. acanthophora* differs from *P. falcata* and *P. adunca* (Sowerby, 1834), a closely related form, in having a larger, more open

aperture, with small denticles on the inner side. The Ecuadorian species, in turn, differs from *P. acanthophora* in having an even larger aperture, which sometimes has small denticles, but not in all specimens (including that figured here). *Pteropurpura adunca* and *P. falcata* usually have four varices per whorl; *P. acanthophora* has five, and *P. ecuadoria* has about seven in the adult, although all the species tend to have a larger number in the earlier stages, eight or nine in *P. ecuadoria*.

This is the most common muricid at Quebrada Camarones; between Pitt's and our collections we have 61 specimens. But there are only four from TU 1399, emphasizing what was said in the Introduction concerning the differences in fauna between the two localities. Olsson (1964, p. 140) had three examples from Punta Gorda, and Jung collected two at the Trans-Ecuadorian Pipeline locality mentioned under *Muricopsis oxytata* (above).

Depth data for the Japanese species is sketchy, but in the American Museum of Natural History and the Vokes collections *P. adunca* seems to be the shallower form (6-45 m) and *P. falcata* is slightly deeper (70-130 m). *Pteropurpura acanthophora* was described from 37 fms (68 m), suggesting that it too is a deeper form, and this is probably the depth that the Quebrada Camarones material originally came from (see Introduction).

Genus VITULARIA Swainson, 1840

Vitularia SWAINSON, 1840, Treatise on Malacology, p. 297.

Type species: *Vitularia tuberculata* Swainson, 1840, by original desig. (= *Murex vitulinus* Lamarck, 1816, *fide* Swainson, = *Murex miliaris* Gmelin, 1791).

VITULARIA SALEBROSA (King and Broderip)
Plate 6, figs. 7-9; text fig. 14

Murex salebrosus KING and BRODERIP, 1832, Zool. Jour., v. 5, p. 347; SOWERBY, 1834, Conch. Illus., *Murex*, pl. 58, fig. 5 (as "var."); pl. 65, fig. 48; KIENER, 1843, Coq. Viv., v. 7, *Murex*, p. 121, pl. 47, figs. 1, 1a; REEVE, 1845, Conch. Icon., v. 3, *Murex*, pl. 24, figs. 98a, 98b.

Murex (Vitularia) salebrosus King and Broderip. ADAMS and ADAMS, 1853, Gen. Recent Moll., v. 1, p. 74; TRYON, 1880, Man. Conch., v. 2, p. 133, pl. 35, figs. 394, 396, 398 (as *salebrosa*).

Vitularia salebrosa (King and Broderip). CARPENTER, 1857, Cat. Mazatlan, p. 485; BRANN, 1966, Illus. to "Cat. Mazatlan," pl. 51, figs. 612, 2290, 2294, 2298, 2301, 2302; KEEN, 1958, Sea Shells Trop. West Amer., ed. 1, p. 363, fig. 370; KEEN, 1971, *ibid.*, ed. 2, p. 536, fig. 1040; DUSHANE and POORMAN, 1967, Veliger, v. 9, p. 429; VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 90; RADWIN and D'ATTILIO, 1976, *Murex* Shells of the World, p. 173, pl. 7, fig. 14, text-figs. 113 (radula), 114 (protoconch), 115 (microsculpture); FAIR, 1976, *Murex* Book, p. 74, pl. 20, fig. 283; VOKES, 1977, Tulane Stud. Geol. Paleont., v. 13, no. 4, p. 192, text-fig. 5 (protoconch); VOKES 1986, Conch. Amer. Bull., v. 14, no. 2, p. 19, figs. 1, 7; BALDAZZI *et al.*, 1986, La Conchiglia, v. 18, nos. 212-213, p. 6.

Vitularia cf. *salebrosa* (King and Broderip). OLSSON, 1942, Bulls. Amer. Paleontology, v. 27, no. 106, p. 170.

Vitularia salebrosa extensa M. SMITH, 1947, Nautilus, v. 61, p. 54, pl. 2, fig. 5.

Vitularia ecuadorana MARKS, 1951, Bulls. Amer. Paleontology, v. 33, no. 139, p. 389, pl. 50, fig. 12; VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 90; VOKES, 1977, Tulane Stud. Geol. Paleont., v. 13, no. 4, p. 192 (as "*equadorana*"); VOKES, 1986, Conch. Amer. Bull., v. 14, no. 2, p. 19, fig. 2 (holotype).

Muricidea (Vitularia) salebrosa (King and Broderip). M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 12, pl. 4, fig. 11.

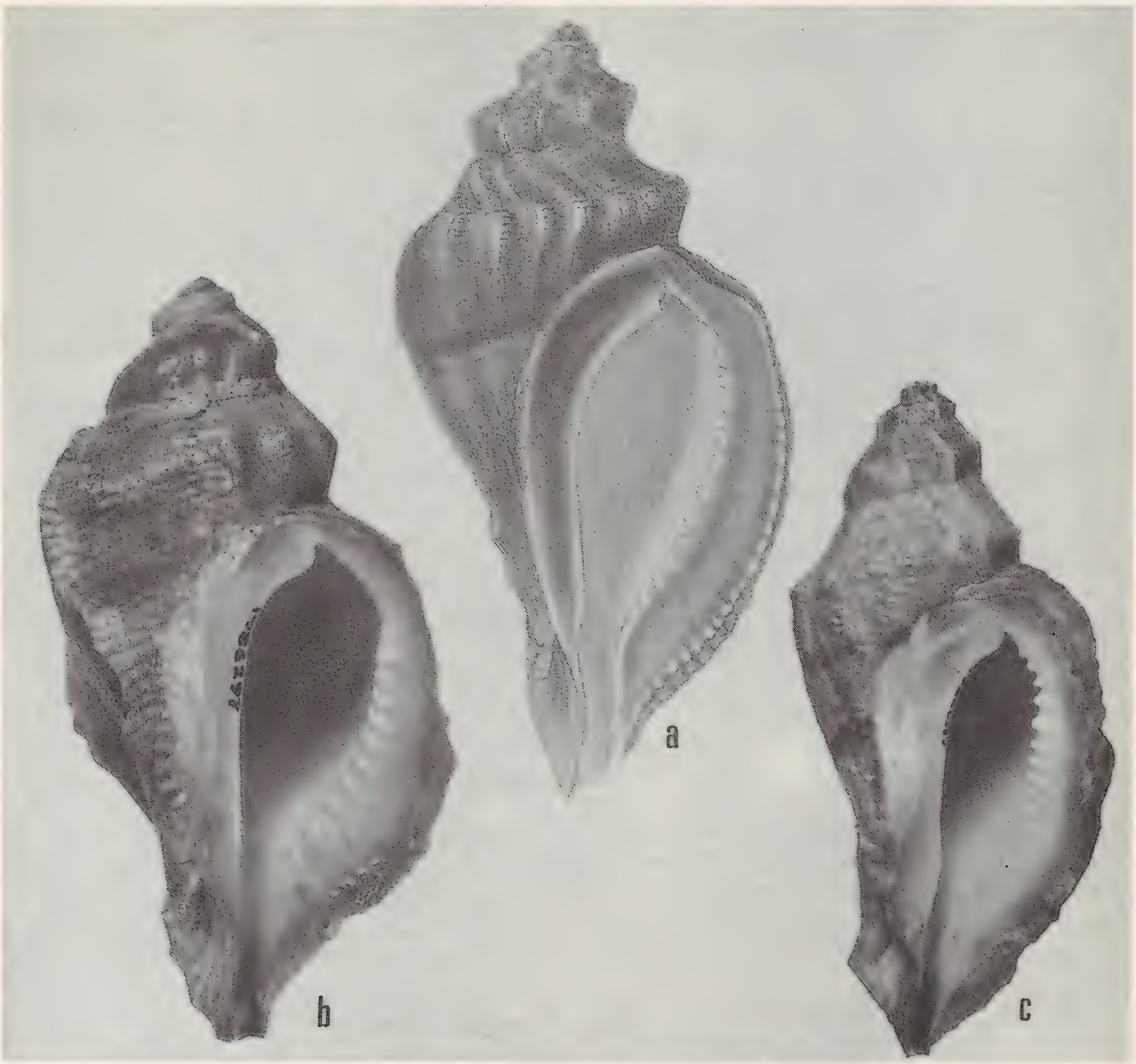
Vitularia linguabison VOKES, 1967, Tulane Stud. Geol., v. 5, no. 2, p. 91, text-fig. 1; VOKES, 1977, Tulane Stud. Geol. Paleont., v. 13, no. 4, p. 192, text-fig. 4; VOKES, 1986, Conch. Amer. Bull., v. 14, no. 2, p. 19, figs. 4, 8; PETUCH, 1986, Jour. Coastal Resh., v. 2, no. 4, p. 396, figs. 8-11 (figs. 10, 11 as *V.* cf. *linguabison*).

Lectotype (?): BMNH 1986297; height 90.1 mm, diameter 50.3 mm ("long. 3 7/16; lat. 2; poll."). See discussion below.

Type locality: "Southern coasts of South America" (King and Broderip, 1832); "Panama (found under stones); Cuming" (Reeve, 1845, pl. 24).

Occurrence: Daule Formation (of Marks, 1951) and Esmeraldas beds, Ecuador. Pinecrest beds, Florida; Agueguexquite Formation, Mexico; Pliocene. Charco Azul Formation, Panama; Pleistocene. Recent, Baja California to Súa, Ecuador (TU R-532), and Galápagos (*fide* Radwin and D'Attilio, 1976, p. 174).

Figured specimens: Fig. 7, PRI 20481 (holotype – *V. ecuadorana* Marks); height 59.1 mm, diameter 30.5 mm; locality, Daule,



Text-figure 14. *Vitularia salebrosa* (King and Broderip). a) Illustration from Sowerby, 1834, *Conchological Illustrations*, pl. 65, fig. 48 (height 90 mm). b,c) Possible type material in British Museum (Natural History); b, lectotype?; height 90.1 mm, diameter 50.3 mm; c, paralectotype?; height 79.7 mm, diameter 36.2 mm.

Ecuador. Fig. 8; USNM 418060; height 20.9 mm, diameter 13.8 mm; locality TU 1399. Fig. 9, USNM 418061; height 19.1 mm, diameter 10.6 mm; locality TU 1399.

Discussion: The writer (Vokes, 1986) has discussed the identity of three "species" of *Vitularia: V. linguabison* Vokes, from the mid-Pliocene beds of Florida and Mexico; *V. ecuadorana* Marks, from the mid-Pliocene "Daule Formation" of Ecuador; and the Pleistocene to Recent *V. salebrosa*. The conclusion was that all three are the same species, for which *V. salebrosa* is the oldest name.

This conclusion was largely brought about by the discovery, in the Esmeraldas beds, of two small examples of *Vitularia*, one with protoconch preserved, that demonstrate the link between *V. ecuadorana* and *V. salebrosa*. At about the same time, additional high-spired examples of the Atlantic *V. linguabison* indicated that this form was also part of the same complex. As the Atlantic and Pacific *V. linguabison* and *V. ecuadorana* are now known to be correlative in age, this is not unreasonable.

Thus, we have another species in common between the Esmeraldas beds and the mid-Pliocene Pinecrest beds of Florida.

According to Keen (1971, p. 536), the Recent *V. salebrosa* ranges only as far south as Gorgona Island, Colombia; however, Baldazzi *et al.* (1986, p. 6) have reported the occurrence at Camarones, Ecuador, and we have beach specimens from Súa, Ecuador (TU R-532). This is another of the down-slope transported elements of the Esmeraldas fauna; DuShane and Poorman (1967, p. 429) report that the species was taken "just below low tide on base of gorgonians; dredged 15-17 fms [27-31 m] on rock bottom."

In the collections of the British Museum (Nat. Hist.) there is a lot of three specimens, which may be the type material of this species. The original label with these shells reads: "*M. salebrosus* King, Zool. Jour., p. 347, Sow. Con. Ill. f. 5 var. f. 48 – Southern coast of America." But examination of the specimens shows that the Sowerby drawing given in fig. 48 is evidently a composite of the two larger shells (see text-fig. 14); however, the third is not the one in his fig. 5. Because the dimensions of the largest specimen so nearly match those in the original description, it seem probable that this is the type lot, and the largest specimen is here tentatively designated as lectotype.

Subfamiy TYPHINAE Cossmann, 1903
Genus TYPHIS Montfort, 1810

Typhis MONTFORT, 1810, Conchyl. Syst., v. 2, p. 614-615.

Type species: *Typhis tubifer* (Bruguière, 1792), by original desig.

Subgenus TALITYPHIS Jousseaume, 1882

Talityphis JOUSSEAUME, 1882, Rev. Mag. Zool., (Ser. 3) v. 7, p. 338.

Type species: *Typhis expansus* Sowerby, 1874, by original desig.

TYPHIS (TALITYPHIS) LATIPENNIS Dall
Plate 6, figs. 1, 2; text-fig. 15

Typhis latipennis DALL, 1919, U. S. Natl. Mus., Proc., v. 56, no. 2295, p. 339; M. SMITH, 1953, Illus. Cat. Recent Species Rock Shells, p. 18, pl. 14, fig. 9 (holotype).

Typhis (Talityphis) latipennis Dall. WOODRING, 1928, Carnegie Inst. Washington, Publ. 385, p. 295; KEEN, 1943, San Diego Soc. Nat. Hist., Trans., v. 10, no. 2, p. 53, pl. 3, figs. 17, 21, 24, 25; KEEN, 1958, Sea Shells Trop. West Amer., ed. 1, p. 367, fig. 382; KEEN, 1971, *ibid.*, ed. 2, p. 539, fig. 1049; KEEN and CAMPBELL, 1964, Veliger, v. 7, p. 50, pl. 9, fig. 13; Vokes, 1984, Shells and Sea Life, v. 16, no. 11, p. 214, pl. 1, fig. 25.

Talityphis latipennis (Dall). RADWIN and D'ATTILLIO, 1976, *Murex* Shells of the World, p. 201, pl. 30, figs. 13, 14, text-fig. 147 (radula).

Holotype: USNM 96653; height (incomplete) 28.9 mm, diameter 23.8 mm (this specimen is now lost, see discussion below).

Type locality: U. S. Fish Comm. Station 2822, Bahía de La Paz, Baja California, 21 fms (38 m).

Occurrence: Esmeraldas beds, Ecuador. Gatun Formation, Panama; Pliocene. Recent, Gulf of California to Panama.

Figured specimens: Fig. 1, USNM 418057; height 27.0 mm, diameter 20.4 mm; locality TU 1397. Fig. 2, USNM 859926; height 32.5 mm, diameter 19.0 mm; locality, El Dorado, Jalisco, Mexico, 51 m.

Discussion: In the Plio-Pleistocene of the western Atlantic there are three species of *Talityphis* that have given authors no end of trouble, as they are all extremely similar in morphology. The oldest (stratigraphically) of the group is *T. obesus* Gabb, 1873, described from the Early Miocene Baitoa Formation of the Dominican Republic (see Vokes, 1979, p. 112), but also occurring in the correlative Early Miocene Chipola Formation of Florida and the mid-Pliocene Gatun Formation of Panama. But the first named is *Typhis alatus* Sowerby, 1850, which was described from the Gurabo Formation of the Dominican Republic but also has been taken in the Gatun (Vokes, 1983, p. 124) and in the "Picaderos" [=Onzole] Formation of Ecuador by Olsson (1964, p. 141). Because of priority, the name *T. alatus* has been used for a variety of occurrences of other species of *Talityphis*, such as that of *T. expansus* Sowerby, 1874, in the Pleistocene of Bowden, Jamaica (Woodring, 1928, p. 294, pl. 18, figs. 3, 4, as *T. alatus obesus*), and Moín, Costa Rica (Olsson, 1922, p. 132, pl. 13, fig. 15), and in the Recent (Bullis, 1964, p. 107).

Although all are similar, there are differences that may be used to distinguish these three forms. *Typhis obesus*, as the name indicates, is very inflated, with a relatively low spire compared to the other two. Between the two narrower, high-spired

forms, *T. alatus* may be distinguished immediately by the swelling or axial node adjacent to the intervarical tube. It is also less triangular in outline than either *T. obesus* or *T. expansus*.

Into this picture comes *Typhis latipennis* Dall, heretofore only known from the Recent fauna from Baja California to Panama. But in the collections from the Esmeraldas area we have several specimens (TU 1397-3; TU 1399-6) that prove to be *T. latipennis* and not, as might be anticipated, either *T. obesus* or *T. alatus*. Again, the differences between the forms are extremely subtle, and no one has ever attempted to define them. Dall, in the original description of *T. latipennis* simply says: "It is obviously distinct from either of the species yet described from this region." Radwin and D'Attilio (1976, p. 236) in their description of *Talityphis perchardei* (a synonym of *T. expansus;* see Vokes, 1984, note 17) say only that their new species "must be considered a Caribbean cognate of the Panamic *T. latipennis*."

In a comparison of cognate species, the writer (Vokes, 1984, pl. 1, figs. 25, 26) has given illustrations of *T. latipennis* and *T. expansus*, which show that the main difference between the two is a less triangular shape in *T. expansus* (due to the fact that the varix is less recurved dorsally) with a greater distance between the tube and the varical spine and stronger spiral ornamentation also in the Caribbean species. The aperture is relatively larger in *T. latipennis*, and this suggests that *T. latipennis* is closer to *T. obesus* than it is to *T. expansus*. If one compares the specimen of *T. obesus* figured by Vokes (1983, pl. 1, fig. 4) from the Gatun Formation, with *T. latipennis*, it may be seen that the two differ only in the even larger aperture in *T. obesus*. The not-so-close relationship between *T. latipennis* and *T. expansus* is more dramatically demonstrated by illustrations of the quite different radulae of the two species, given by Radwin and D'Attilio (1976, text-figs. 147 and 192, respectively).

Because of the same confusion of *T. alatus/obesus* and *T. expansus*, Keen (1943, p. 54) compared her new species *T. lampada* to the specimen of "*T. alatus*" figured by Olsson (1922, pl. 13, fig. 15) from the "Gatun Formation" of Toro Cay, Panama.

Text-figure 15. *Typhis (Talityphis) latipennis* Dall. Holotype, USNM 96653; height (incomplete) 28.9 mm, diameter 23.8 mm (X 2).

But Olsson's shell is a specimen of *T. expansus* from the Pleistocene Moín Formation and not *T. obesus* (or *T. alatus*). Keen's *T. lampada* is very close to *T. obesus*, differing in having an even larger aperture than either *T. obesus* or *T. latipennis*. Thus, one may make the assumption that *T. obesus* was the ancestral stock, which entered the Pacific early in the Neogene, there to give rise to *T. lampada* in the north (Round Mountain Silt, Miocene, of Kern Co., California) and *T. latipennis* in the more tropical area.

In the Pleistocene Charco Azul Formation of the Burica Peninsula, Panama/Costa Rica, there is another species of *Talityphis: T. olssoni* Keen, 1943 (new name for *T. costaricensis* Olsson, 1942b, *non T. costaricensis* Olsson, 1922). Known only from the holotype (PRI 4064) this species is much like *T. latipennis*, but seems to have a narrower shell, with stronger spiral ornamentation. Without more material it will not be placed in synonymy, but the possibility should be noted.

Typhis (Talityphis) latipennis is another Esmeraldas species that occurs today only as far south as Panama. It is generally found in moderate depths of about 50 m.

This is the same depth as the Atlantic *T. expansus* and so it is assumed that *T. latipennis* is the ecologic cognate of *T. expansus*, even though it may result from parallel evolution from an ancestral *T. obesus*, which appears to have occupied much shallower water.

The holotype of *T. latipennis* was a badly damaged specimen, with most of the siphonal canal missing. The verb *was* is used here because while the specimen (USNM 96653) was in the hands of the writer, in preparation of this paper, it suffered what insurance companies term a "mysterious disappearance." In a word, it was lost! Dall never figured the species, but an apertural view of the holotype was subsequently figured by M. Smith (1953, pl. 14, fig. 9). An abapertural view is given here in text-fig. 15. A replacement specimen has been placed in the collections of the USNM (USNM 859929), but it is not a neotype, as the ICZN Code (Art. 75a) specifically advises that a neotype is only to be designated when it is necessary "in the interests of stability of nomenclature." As there is no question about the identity of *T. latipennis* Dall, the replacement is simply a "reference specimen."

TYPHIS (TALITYPHIS) ALATUS Sowerby
Plate 6, figs. 3, 4

Typhis alatus G. B. SOWERBY, 1850, Geol. Soc. London, Quart. Jour., v. 6, p. 48, pl. 10, fig. 4.

Typhis (Talityphis) alatus Sowerby. OLSSON, 1964, Neogene Moll. Northwest. Ecuador, p. 141; GERTMAN, 1969, Tulane Stud. Geol. Paleont., v. 7, no. 4, p. 159, text-fig. 3 (holotype); VOKES, 1983, Tulane Stud. Geol. Paleont., v. 17, no. 4, p. 124, pl. 1, figs. 1-3.

Holotype: British Museum (Nat. Hist.) GG. 20084; height 29.5, diameter 18.0 mm.

Type locality: Gurabo Formation; Rio Yaque, Dominican Republic (designated by Gertman, 1969, p. 160).

Occurrence: Esmeraldas beds, Angostura, and "Picaderos" [=Onzole] formations, Ecuador. Unnamed Middle Miocene Formation, Dominican Republic. Gatun Formation, Panama; Gurabo Formation, Dominican Republic; Pliocene.

Figured specimens: Fig. 3, USNM 418058; height 26.7 mm, diameter (incomplete) 13.2 mm; locality TU 1399. Fig. 4, USNM 323910; height 27.7 mm, diameter 17.3 mm; locality TU 1212.

Discussion: Olsson (1964, p. 141) reported a single specimen of *Typhis alatus* from the "Picaderos" Formation on the Rio Santiago, Ecuador. Although it is obvious from his synonymy that he included both *T. obesus* and *T. expansus* in his concept of the species, examination of his specimen (USNM 645453) shows that it is *T. alatus*, although of smaller than normal size.

Collections made by us in Ecuador yielded a second specimen of *T. alatus* from the Angostura Formation at Punta Verde (TU 1507), and a third rather battered and incomplete example from TU 1399, west of Camarones. The presence of *T. alatus* in these beds is a slight geographic extension of range, but as the species occurs in the Middle Miocene of the Dominican Republic (unnamed formation, figured in Vokes, in press), the Early Pliocene Gurabo Formation and in the mid-Pliocene Gatun Formation of Panama (see Vokes, 1983), it does not provide any new stratigraphic information.

In the Atlantic the species usually is found in deeper water deposits than the correlative *T. obesus*, although we have a single example from the shallowest beds of the Gatun (TU 1431; see Vokes, 1983, pl. 1, fig. 2). The beds at Picaderos would seem to be similar in environment of those of the Gurabo Formation, as Olsson (1964, p. 10) listed *Sconsia laevigata* (Sowerby), a common Gurabo form that usually occurs with *T. alatus* in beds that are judged to be deposited in between 50 and 150 meters, and *Gemmula vaningeni* (Brown and Pilsbry), which the writer has previously noted (Vokes, 1983, p. 123) is most closely related to the Recent *G. hindsiana* Berry, living in depths of 40 to 70 meters. Presumably the specimen at Camarones was collected by a gravity-flow in its passage through waters of these depths.

V. LOCALITY DATA

The following are Tulane University fossil locality numbers:

202. Caloosahatchee Fm., south bank of Caloosahatchee River, about two miles west of La Belle (SE 1/4 Sec. 12, T43S, R28E), Hendry Co., Florida.

541. Pinecrest beds and Caloosahatchee Fm. mixed, Miami Canal spoil banks, two miles

north of pumping station at Broward County line, Palm Beach Co., Florida.

705. Bowden Fm., type locality, Bowden, east of Port Morant, Parish of St. Thomas, Jamaica.

726. Caloosahatchee Fm., Hendry County rock pit, 1/2 mile north of Florida Highway 80, three miles west of La Belle (SE 1/4 Sec. 14, T43S, R28E), Hendry Co., Florida.

757. Gatun Fm., roadcut on south side of Boyd-Roosevelt Highway at junction of road to "Refinería Panamá, S.A.," just east of Cativá, Prov. of Colón, Panamá.

768. Caloosahatchee Fm. and Bermont Fm. mixed, spoil banks north side of Caloosahatchee River, 5 1/2 miles west of Ortona Lock (NW 1/4 Sec. 35, T42S, R29E), Glades Co., Florida.

797. Pinecrest beds, material exposed during construction of "Alligator Alley," 13.3 miles east of Florida Highway 29 (T49S, R32E), Collier Co., Florida.

953. Moín Fm., type locality, Moín Hill, railroad cut and adjacent ditches on road to Sandoval, 4.5 km west of Puerto Limón, Costa Rica.

954. Moín Fm., hill cut immediately behind Standard Fruit Co. box factory, just west of cemetery at Pueblo Nuevo, about 2 km west of Puerto Limón, Costa Rica.

958. Gatun Fm., hillslope on east side of road from Boyd-Roosevelt Highway to "Refinería Panamá, S.A.," about 1/2 km north of junction, just east of Cativá, Prov. of Colón, Panamá.

1000. Pinecrest beds, borrow pit at east end of 17th street, (variously Warren Bros., Macasphalt, etc.), (T36S, R19E), about 8 miles east of U.S. Highway 301 at Sarasota, Sarasota Co., Florida.

1212. Gurabo Fm., Rio Gurabo, east bank, third bluff below the ford on Los Quemados-Sabaneta road, Dominican Republic.

1240. Moín Fm., Barrio Los Corales, top of hill at end of road that passes Standard Fruit Co. box factory (see TU 954), 1.8 kms north of main highway at Pueblo Nuevo, which is 2 kms west of Puerto Limón, Costa Rica.

1307. Moín Fm., hill top approximately halfway between Puerto Limón and Barrio Los Corales and about 0.5 km north of highway at Pueblo Nuevo, Costa Rica.

1397. Esmeraldas beds, Quebrada Camarones, cut-bank on east side of canyon, which is at east edge of village of Camarones, 20 km (by road) east of bridge over Rio Esmeraldas, at Esmeraldas, *or* approximately 10 km east of mouth of Rio Esmeraldas, Prov. of Esmeraldas, Ecuador.

1398. Esmeraldas beds, roadcut at mouth of Quebrada Camarones, east side of bridge at village of Camarones, which is 20 km (by road) east of bridge over Rio Esmeraldas, at Esmeraldas, Prov. of Esmeraldas, Ecuador.

1399. Esmeraldas beds, roadcut on west side of village of Camarones, which is 20 km (by road) east of bridge over Rio Esmeraldas, at Esmeraldas, Prov. of Esmeraldas, Ecuador.

1431. Gatun Fm., hilltop construction site, 0.5 km northwest of intersection of Boyd-Roosevelt Highway and road to Puerto Pilon, at Sabanita, Prov. of Colón, Panamá.

1432. Gatun Fm., north side of Boyd-Roosevelt Highway, clearing behind Residential Martin Luther King (formerly Palo Quemado), approximately 1.5 km east of junction of road to "Refinería Panamá, S.A.," at Cativá, Prov. of Colón, Panamá.

1433. Gatun Fm., north side of Boyd-Roosevelt Highway, clearing behind Urbanization San Martin, approximately 0.5 km east of junction of road to "Refinería Panamá, S.A." at Cativá, Prov. of Colón, Panamá.

1493. Pinecrest beds, Arvita Pit, on Bird Road (= W. 40th St.), approximately 5 miles west of Florida Turnpike, on west side of Coral Gables, Dade Co., Florida.

1499. Charco Azul Fm., Burica Peninsula, beds exposed at low tide, 7 km south of dock at Charco Azul Terminal, Puerto Armuellas, Panamá.

1507. Angostura Fm., Punta Verde, large point just east of Rio Verde, or about 22 km east of Rio Esmeraldas, Prov. of Esmeraldas, Ecuador.

The following are Tulane University Recent locality numbers:

R-56. Beach at Playa de Boca Grande, about 10 miles south of Tumaco, Colombia.

R-109. Fill for refinary, Bahia las Minas, Isla Payardi, Panamá. (Radiocarbon dated at 7000 years B.P.)

R-166. Barra de Navidad, Jalisco, Mexico; rocky point across inlet from main sand bar.

R-173. Puntarenas, Costa Rica.

R-186. Rocks and beach in front of Palo Seco Leper Colony (formerly Canal Zone), Panamá (Pacific Ocean side).

R-381. Beach at Salinas, Bahía de Sta. Elena, Prov. of Guayas, Ecuador.

R-478. Beach at Puerto de Cayo, Prov. of Manabi, Ecuador.

R-484. Beach at Camarones, fishing village about 10 km (airline) east of Rio Esmeraldas, Prov. of Esmeraldas, Ecuador.

R-532. Beach at Súa, which is *ca.* 25 km (airline) west of Esmeraldas, Prov. of Esmeraldas, Ecuador.

R-552. Ayangue, southern end of Ensenada de Valdivia, Prov. of Guayas, Ecuador.

R-553. La Libertad, beach and rocks in front of hotel Samarina, Bahía de Sta. Elena, Prov. of Guayas, Ecuador.

VI. LITERATURE CITED

ABBOTT, R.T., 1958, The marine mollusks of Grand Cayman Island, British West Indies: Acad. Nat. Sci. Phila., Mon. 11, 138 p., 5 pls., 11 maps, 7 text-figs.

BALDAZZI, SERGIO, CESARE DI CECCO, and FRANCO TIBERI, 1986, Contribution to the knowledge of the shells of Ecuador: La Conchiglia, Year 18, nos. 212-213, p. 4-7, 3 colored plates, 1 map.

BAYER, F.M., 1971, New and unusual mollusks collected by R/V *John Elliot Pillsbury* and R/V *Gerda* in the tropical western Atlantic: Bull. Marine Sci., v. 21, no. 1, p. 111-236, figs. 1-72.

BERGGREN, W.A., 1973, The Pliocene time scale: Calibration of planktonic foraminiferal and calcareous nannoplankton zones: Nature, v. 243, no. 5407, p. 391-397, 1 text-fig., 5 tables.

BRISTOW, C.R., 1976, The Daule Group, Ecuador (Middle Miocene-Pliocene): Newsl. Stratigr., v. 5, nos. 2/3, p. 190-200, 2 text-figs.

BRISTOW, C.R., and ROBERT HOFFSTETTER, 1977, Ecuador: *in* Lexique Stratigraphique International, Second Edition, v. 5, Amerique Latine, fasc. 5A2, 410 p.

BRODERIP, W.J., 1833, Characters of new species of Mollusca and Conchifera collected by Mr. Cuming: Zool. Soc. London, Proc. Comm. Sci., pt. 2 (1832), p. 173-179.

BULLIS, H.R., JR., 1964, Muricidae (Gastropoda) from the northeast coast of South America, with descriptions of four new species: Tulane Stud. Zoology, v. 11, no. 4, p. 99-107, 1 pl., 2 tables.

CLENCH, W.J., and I. PÉREZ FARFANTE, 1945, The genus *Murex* in the western Atlantic: Johnsonia, v. 1, no. 17, 58 p., 29 pls.

DURHAM, J. W., 1950, 1940 E. W. Scripps cruise to the Gulf of California - Pt. II, Megascopic paleontology and marine stratigraphy: Geol. Soc. Amer., Mem. 43, vii + 216 p., 48 pls.

DUSHANE, HELEN, and ROY POORMAN, 1967, A checklist of mollusks for Guaymas, Mexico: Veliger, v. 9, p. 413-441.

EMERSON, W.K., 1968, Taxonomic placement of *Coralliophila incompta* Berry, 1960, with the proposal of a new genus, *Attiliosa* (Gastropoda:Muricacea): Veliger, v. 10, p. 379-381, pl. 53, text-figs. 1-5.

EMERSON, W.K., and ANTHONY D'ATTILIO, 1970, Three new species of muricacean gastropods from the eastern Pacific: Veliger, v. 12, p. 270-274, pls. 39, 40, text-figs. 1-4.

EVANS, C.D.R., and J.E. WHITTAKER, 1982, *in* J.K. LEGGETT (ed.), Trench-Forearc Geology: Sedimentation and tectonics on modern and ancient active plate margins: Geol. Soc. Amer., Special Paper 10, p. 191-198, 2 text-figs.

FAIR, R.H., 1976, The *Murex* Book, an illustrated catalogue of Recent Muricidae (Muricinae, Muricopsinae, Ocenebrinae). Privately printed, Honolulu, Hawaii. 138 p., 23 pls., 67 text-figs.

GABB, W.M., 1873, On the topography and geology of Santo Domingo: Amer. Phil. Soc. Trans., (N.S.) v. 15, pt. 1, p. 49-259, 2 maps.

GABB, W.M., 1881, Descriptions of new species of fossils from the Pliocene Clay Beds between Limon and Moen, Costa Rica (etc.): Acad. Nat. Sci. Phila., Jour., (Ser. 2) v. 8, no. 4, p. 349-380, pls. 45-47.

GERTMAN, R.L., 1969, Cenozoic Typhinae (Mollusca:Gastropoda) of the western Atlantic region: Tulane Stud. Geol. Paleont., v. 7, no. 4, p. 143-191, pls. 1-8, 3 text-figs.

GIVENS, C.R., and M.P. KENNEDY, 1976, Middle Eocene mollusks from northern San Diego County, California: Jour. Paleontology, v. 50, p. 954-975, pls. 1-4, 2 text-figs., 2 tables.

HAMAN, DREW, and BARRY KOHL, 1986, Early Pliocene *Montfortella* (Foraminiferida) from Ecuador: Tulane Stud. Geol. Paleont., v. 19, no. 4, p. 181-183, 1 pl.

HASSON, P. F., and A.G. FISCHER, 1986, Observations on the Neogene of northwestern Ecuador: Micropaleontology, v. 32, p. 32-42, 1 pl., 9 tables, 1 text-fig.

HERTLEIN, L.G., and A.M. STRONG, 1955, Marine mollusks collected during the "Askoy" Expedition to Panama, Colombia, and Ecuador in 1941: Amer. Mus. Nat. Hist., Bull., v. 107, Art. 2, p. 159-318, pls. 1-3.

JONES, D.S., and P.F. HASSON, 1985, History and development of the marine invertebrate faunas separated by the Central American Isthmus, *in* F.G. STEHLI and S.D. WEBB, eds., The Great American Biotic Interchange, p. 325-355, 6 text-figs., 3 tables.

JUNG, PETER, 1965, Miocene Mollusca from the Paraguana Peninsula, Venezuela: Bulls. Amer. Paleontology, v. 49, no. 223, p. 385-652, pls. 50-79, 2 tables, 2 text-figs.

KEEN, A.M., 1943, New mollusks from the Round Mountain Silt (Temblor) of California: San Diego Soc. Nat. Hist., Trans., v. 10, no. 2, p. 25-60, pls. 3,4.

KEEN, A.M., 1958, Sea shells of tropical west America. Stanford University Press, Stanford, California. xi + 624 p., 10 color plates, 1709 figs., 6 text-figs.

KEEN, A.M., 1971, Sea shells of tropical west America, Marine mollusks from Baja California to Peru. Second Edition. Stanford University Press, Stanford, California. xiv + 1064 p., 22 color plates, *ca.* 4000 figures, 6 maps.

KEEP, JOSIAH, 1935, West Coast Shells (Re-

vised by J.L. Baily, Jr.), 350 p., 334 text-figs.

KEIGWIN, L.D., JR., 1978, Pliocene closing of the Isthmus of Panama, based on biostratigraphic evidence from nearby Pacific Ocean and Caribbean Sea cores: Geology, v. 6, p. 630-634, 3 text-figs.

KIENER, L.C., 1843, Spécies général et iconographie des coquilles vivantes . . . famille des canaliferes, troisieme partie, Genre Rocher. Paris. 130 p., 47 pls.

MAXWELL, P.A., 1971, Notes on some Cenozoic Muricidae (Mollusca:Gastropoda) from New Zealand, with a review of the genus *Poirieria* Jousseaume, 1880: New Zealand Jour. Geol. Geophs., v. 14, no. 4, p. 757-781, figs. 1-32.

MCLEAN, J.H., 1978, Marine shells of southern California: Nat. Hist. Mus. Los Angeles County, Science Ser. 24, Revised Ed., 104 p., 54 text-figs.

OLSSON, A.A., 1922, The Miocene of northern Costa Rica: Bulls. Amer. Paleontology, v. 9, no. 39, p. 174-460, pls. 4-35.

OLSSON, A.A., 1942a, Tertiary deposits of northwestern South America and Panama: Eighth American Sci. Cong., Proc., v. 4, p. 231-287.

OLSSON, A.A., 1942b, Tertiary and Quaternary fossils from the Burica Peninsula of Panama and Costa Rica: Bulls. Amer. Paleontology, v. 27, no. 106, p. 153-258, pls. 14-25.

OLSSON, A.A., 1964, Neogene mollusks from northwestern Ecudor. Paleontological Research Institution, Ithaca, New York. 256 p., 38 pls.

OLSSON, A.A., 1971, Mollusks from the Gulf of Panama collected by R/V *John Elliott Pillsbury*, 1967: Bull. Marine Sci., v. 21, no. 1, p. 35-92, figs. 1-103.

PETUCH, E.J., 1982, Geographic heterochrony: Contemporaneous coexistance of Neogene and Recent molluscan faunas in the Americas: Palaeogeog., Palaeoclim., Paleoecol., v. 37, p. 277-312, 12 text-figs., 2 tables.

PETUCH, E.J., 1986, The Pliocene reefs of Miami: their geomorphological significance in the evolution of Atlantic Coastal Ridge, southeastern Florida, U.S.A.: Jour. Coastal Resh., v. 2, no. 4, p. 391-408, pls. 1-4, 5 text-figs.

PETUCH, E.J., 1987, New Caribbean molluscan faunas. Coastal Educ. Resh. Found. (CERF), Charlottesville, Virginia. 154 + 4 p., 29 pls.

PILSBRY, H.A., and A.A. OLSSON, 1941, A Pliocene fauna from western Ecuador: Acad. Nat. Sci. Phila., Proc., v. 93, p. 1-79, pls. 1-19.

PONDER, W.F., 1972, Notes on some Australian genera and species of the family Muricidae (Neogastropoda): Malac. Soc. Australia, Jour., v. 2, no. 3, p. 215-248, pls. 20-23, text-figs. 1-4.

PONDER, W.F., and E.H. VOKES, 1988, A revision of the Indo-West Pacific fossil and Recent species of *Murex* s.s. and *Haustellum* (Muricidae: Gastropoda: Mollusca): Rec. Australian Mus., Suppl. 8, 160 p., 89 text-figs., 57 tables.

RADWIN, G.E., and ANTHONY D'ATTILIO, 1971, Muricacean supraspecific taxonomy based on the shell and the radula: Echo, no. 4, p. 55-67, 23 text-figs.

RADWIN, G.E., and ANTHONY D'ATTILLIO, 1976, *Murex* shells of the world; an illustrated guide to the Muricidae. Stanford University Press, Stanford, California. 284 p., 32 pls., 192 text-figs.

RADWIN, G.E., and ANTHONY D'ATTILIO, 1978, Comments on subfamilial relationships in two amphi-American muricid genera – *Acanthotrophon* and *Attiliosa:* Tulane Stud. Geol. Paleont., v. 14, no. 3, p. 131-134, figs. 1-7.

REEVE, L.A., 1845-1846, Conchologia Iconica, v. 3, *Murex,* 36 pls. (pls. 1-34 issued Apr. to Oct., 1845; pls. 35, 36 issued Apr., 1846).

ROSENBERG, GARY, 1984, Paleoecology and molluscan fauna of the Esmeraldas Formation of Ecuador: Amer. Malac. Bull., v. 2, p. 84 [abstract].

SAITO, TSUNEMASA, 1976, Geologic significance of coiling direction in the planktonic foraminifera *Pulleniatina:* Geology, v. 4, p. 305-309, 3 text-figs.

SKOGLUND, CAROL, 1983, Range extensions of Muricidae in the Gulf of California: Festivus, v. 15, no. 11, p. 107-108, figs. 1-4.

SMITH, MAXWELL, 1953, An illustrated catalog of the Recent species of the Rock Shells: Muricidae, Thaisidae, and Coralliophilidae. Tropical Laboratory, Windermere, Florida. 84 p., 23 pls., text-figs. a-z2. [A revised edition of the 1939 book of the same name.]

SOWERBY, G.B., JR., 1834-1841, Conchological Illustrations, pls. 58-67 (issued in 1834); pls. 187-199 (issued in 1841); *Murex:* Catalogue of Recent species, 9 p., included.

SUTTY, LESLEY, 1986, Seashell Treasures of the Caribbean. E.P. Dutton, New York. 128 p., 139 colored figures.

TRYON, G.W., JR., 1880, Manual of Conchology, v. 2, Muricinae, Purpurinae. Philadelphia. 289 p., 70 pls.

VERRILL, A.H., 1950, A new *Murex* from the West Indies: Conchological Club So. Calif., Mins., no. 103, p. 4.

VOKES, E.H., 1963, Cenozoic Muricidae of the western Atlantic region. Part I – *Murex* sensu stricto: Tulane Stud. Geol., v. 1, no. 3, p. 93-123, pls. 1-4.

VOKES, E.H., 1964, Supraspecific groups in the subfamilies Muricinae and Tritonaliinae (Gastropoda:Muricidae): Malacologia, v. 2, no. 1, p. 1-41, pls. 1-3.

VOKES, E.H., 1965, Cenozoic Muricidae of the western Atlantic region. Part II–*Chicoreus* sensu stricto and *Chicoreus (Siratus):* Tulane Stud. Geol., v. 3, no. 4, p. 181-204, pls. 1-3, 2 text-figs.

VOKES, E.H., 1966, Observations on *Turbinella scolymoides* Dall, with description of a new species of *Turbinella:* Tulane Stud. Geol., v. 4, no. 2, p. 63-71, pls. 1-3.

VOKES, E.H., 1967a, Observations on *Murex messorius* and *Murex tryoni,* with the description of two new species of *Murex:* Tulane Stud. Geol., v. 5, no. 2, p. 81-90, pls. 1-4.

VOKES, E.H., 1967b, Cenozoic Muricidae of the western Atlantic region. Part III – *Chicoreus (Phyllonotus):* Tulane Stud. Geol., v. 5, no. 3, p. 133-166, pls. 1-6, 1 table.

VOKES, E.H., 1968, Cenozoic Muricidae of the western Atlantic region. Part IV – *Hexaplex* and *Murexiella:* Tulane Stud. Geol., v. 6, no. 3, p. 85-126, pls. 1-8, 1 text-fig.

VOKES, E.H., 1970, The West American species of *Murexiella* (Gastropoda; Muricidae), including two new species: Veliger, v. 12, p. 325-329, pl. 50.

VOKES, E.H., 1971, The geologic history of the Muricinae and the Ocenebrinae: Echo, no. 4, p. 37-54, 6 text-figs.

VOKES, E.H., 1979, The age of the Baitoa Formation, Dominican Republic, using Mollusca for correlation: Tulane Stud. Geol. Paleont., v. 15, no. 4, p. 105-116, pls. 1,2; 2 text-figs.

VOKES, E.H., 1980, Review of the muricid genus *Acanthotrophon* (Mollusca: Gastropoda): Veliger, v. 23, p. 10-14, figs. 1-18.

VOKES, E.H., 1983, Additions to the Typhinae (Gastropoda: Muricidae) of the Gatun Formation, Panama: Tulane Stud. Geol. Paleont., v. 17, no. 4, p. 123-130, pl. 1.

VOKES, E.H., 1984, Comparison of the Muricidae of the eastern Pacific and western Atlantic, with cognate species: Shells and Sea Life, v. 16, no. 11, p. 210-215, 2 pls., 10 color figs.

VOKES, E.H., 1986, The short happy life of *Vitularia linguabison:* Conch. of Amer., Bull., v. 14, no. 2, p. 19-22, 8 text-figs.

VOKES, E.H., *in press*, Neogene Paleontology in the northern Dominican Republic; Part o: Muricidae (Mollusca:Gastropoda): Bulls. Amer. Paleontology, 245 MS pp., 12 pls., 21 text-figs.

VOKES, E.H., and ROLAND HOUART, 1986, An evaluation of the taxa *Muricopsis* and *Risomurex* (Gastropoda:Muricidae), with one new species of *Risomurex:* Tulane Stud. Geol. Paleont., v. 19, no. 2, p. 63-88, pls. 1-4.

WILMARTH, M.G., 1938, Lexicon of geologic names of the United States: U.S. Geol. Survey, Bull. 896, 2396 p.

WOODRING, W.P., 1928, Miocene mollusks from Bowden, Jamaica; part 2, Gastropods and discussion of results: Carnegie Inst. Washington, Publ. 385, 564 p., 40 pls.

WOODRING, W.P., 1959, Geology and paleontology of Canal Zone and adjoining parts of Panama; Description of Tertiary mollusks (Gastropods:Vermetidae to Thaididae): U.S. Geol. Survey, Prof. Paper 306-B, p. 147-239, pls. 24-38.

WOODRING, W.P., 1966, The Panama land bridge as a sea barrier: Amer. Phil. Soc., Proc., v. 110, no. 6, p. 425-433, 3 figs., 5 tables.

REVIEW

MIGRATION OF SEISMIC DATA, edited by Gerald H. F. Gardner. Published by the Society of Exploration Geophysicists, Tulsa, Oklahoma, Geophysics Reprint Series No. 4, 1985, viii + 462 pp., illustrated, paperbound, $19.00

This reprint volume includes thirty-three papers by a variety of authors, originally published between 1937 and 1984 and chronologically arranged to illustrate the evolution of migration interpretative concepts and methodology through the years. The original ruler-and-compass constructions used in the twenties and thirties have progressed to computer algorithms for depth migration in three dimensions in present interpretative seismology. This reprint series is quite useful in making reference material available on various subjects. The present volume is recommended for reference purposes.

—H.C.S.

PLIOCENE EPITONIIDAE OF THE ESMERALDAS BEDS NORTHWESTERN ECUADOR (MOLLUSCA: GASTROPODA)

HELEN DUSHANE*

RESEARCH ASSOCIATE
NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY
LOS ANGELES, CALIFORNIA

ABSTRACT

Four species of epitoniid gastropods that live today in the Panamic-Galapagan faunal province of the eastern Pacific are here reported from the Pliocene Esmeraldas beds of the Onzole Formation, near the village of Camarones, Esmeraldas Province, northwestern Ecuador.

INTRODUCTION

Four species of epitoniid gastropods [*Amaea (Scalina) ferminiana* (Dall, 1908), *Sthenorytis turbinus* (Dall, 1908), *Sthenorytis dianae* (Hinds, 1844), and *Cirsotrema togatum* (Hertlein and Strong, 1951)] are found in the Pliocene sediments of the Esmeraldas beds, along the northwestern coast of Ecuador (Figure 1). All four species are extant, and live today in the deep-water of the Panamic-Galapagan molluscan faunal province (Guaymas, Mexico, to Peru).

The Esmeraldas Formation was originally named by Olsson (1942, p. 260) for tuffaceous marine mudstones that are extensively exposed along the coast near Esmeraldas, as well as along the Rio Esmeraldas. Bristow (1976, p. 193) noted that several stratigraphic units (formations) are exposed in these areas and, because Olsson (1942) did not establish a type area or type section, he considered that the formation was inadequately defined. As a result of his work the Ecuadorian Geological map uses the name Onzole Formation for the strata. However, because of lithological differences, the name "Esmeraldas beds" will be used herein.

The fossiliferous Esmeraldas unit within the Onzole is Pliocene in age, with Haman and Kohl assigning it an earliest Pliocene age (about 5 million years) on the basis of contained planktic foraminifera and calcareous nannoplankton, and correlating it with Neogene planktic foraminiferal zone N18/19 (Haman and Kohl, 1986, p. 182; Kohl, *in* Vokes, this volume). Hasson and Fischer (1986, p. 36-37), however, concluded that the "Esmeraldas Formation" was largely Zanclian in age - 3.2 to 3.7 million years old - on the basis of its benthic foraminifera.

According to Olsson (1964, p. 7), the Esmeraldas mollusks are mainly species that have a deep-water aspect, and show relationships with Caribbean species, indicative of interoceanic exchanges between the Atlantic-Caribbean and Pacific that occurred during most of the Tertiary. Hasson and Fischer (1986, p. 36) noted that the Esmeraldas mollusks show a diversity of ecological requirements, as well as a wide bathymetric range, attributing this mixing, which would imply considerable downslope transport, to large mollusk-eating vertebrates that distributed their offal widely over the region. The fossiliferous units considered here (TU locs. 1397-1399) more likely represent gravity slides from shallow to deep-water (E. H. Vokes, pers. commun.). A depth range of greater than 700 m is implied by the microplankton, whereas the benthic foraminiferal faunas suggested depths in the 240-900 m range (upper bathyal) (Hasson and Fischer, 1986, p. 39). The known depth ranges for the four species of epitoniids discussed herein

*Mailing Address: 15012 El Soneto Drive, Whittier, California 90605

EDITORIAL COMMITTEE FOR THIS PAPER:
GEORGE L. KENNEDY, Natural History Museum of Los Angeles County, Los Angeles, California
EDWARD C. WILSON, Natural History Museum of Los Angeles County, Los Angeles, California

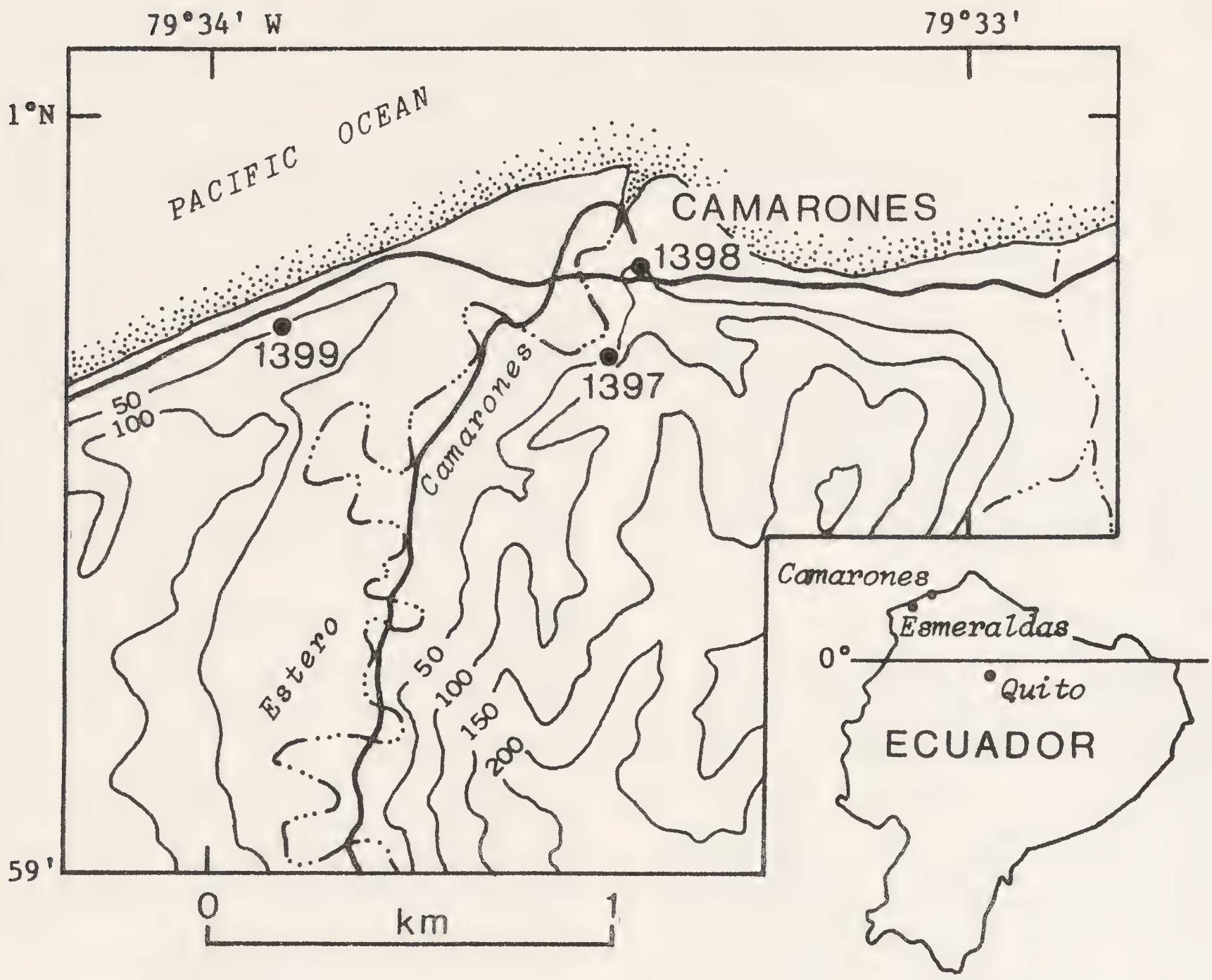


Figure 1. Index map showing position of fossil localities (TU locs. 1397, 1398, and 1399) in Pliocene Esmeraldas beds of the Onzole Formation, near village of Camarones, northwest coast of Ecuador. Contour interval 50 m.

are: 32-113 m, 36-275 m, 65-146 m, and 110-550 m.

ACKNOWLEDGMENTS

I gratefully acknowledge the kindness of Emily Vokes for allowing me the opportunity to work on the Esmeraldas epitoniids, and for providing the photographs of the fossils. William Pitt's contribution of a photograph of *Cirsotrema togatum* is appreciated. George Kennedy and Edward Wilson kindly read the manuscript and helped in manuscript preparation.

The following institutional abbreviations are used herein: CAS, California Academy of Sciences, San Francisco; LACMIP, Natural History Museum of Los Angeles County, Los Angeles; TU, Tulane University, New Orleans; and USMN, U.S. National Museum of Natural History, Washington (D.C.). Figured specimens are deposited in LACMIP (Vokes and Vokes collection), and CAS (Pitt collection).

SYSTEMATIC PALEONTOLOGY

Family EPITONIIDAE Lamarck, 1822 [?1812]

Genus AMAEA Adams and Adams, 1853

Type species: *Scalaria magnifica* Sowerby, 1844, by subsequent designation (Melvill, 1897).

Subgenus SCALINA Conrad, 1865

Type species: *Scalaria staminea* Conrad, 1865, by subsequent designation (Palmer, 1937); Eocene, Alabama. Synonyms: *Ferminoscala* Dall (1908, p. 315); *Elegantiscala* deBoury (1911, p. 216).

Discussion: There is a difference of opinion regarding the use of *Scalina* as a genus or as a subgenus of *Amaea*. There are distinct differences between *Amaea* and *Scalina*, so it seems wise to retain *Scalina* as a subgenus. The type of *Amaea* has a less distinct basal disk below which the sculpture is very different from that above, and is much larger than any known *Scalina*.

The northern limit of *Scalina* in the eastern Pacific is Isla Cedros, Baja California, Mexico; in the late Pleistocene it ranged as far north as the Los Angeles Basin, southern California [*A. (S.) effiae* (Willett, 1939); see DuShane, 1979].

AMAEA (SCALINA) FERMINIANA
(Dall, 1908)
Figures 2, 3

Epitonium (Ferminoscala) ferminiana DALL, 1908, p. 316, pl. 8, fig. 8.
Scala (Acrilla) wiegandi BÖSE, 1910, p. 228, pl. 12, fig. 8.
Epitonium (Ferminoscala) eleutherium PILSBRY and OLSSON, 1941, p. 38, pl. 2, fig. 7.
Amaea (Scala) ferminiana (Dall). KEEN, 1971, p. 438, fig. 672; DUSHANE, 1974, p. 55, figs. 65, 68.

Diagnosis: Shell large, acute, whorls 11 to 15, convex, closely adherent, nuclear whorls disintegrated, early whorls with one strong cord at periphery; subsequent whorls more rounded; suture moderately deep; costae 45 to 50, low, of varying widths; spiral cords intersected by the costae forming small, very unevenly spaced rhomboids within which there are fine axial and spiral threads; basal area defined by a small cord, sculpture the same as on the body whorl but fainter, with the costae more prominent than the spiral scupture; lip thin, patulous; peritreme incomplete.

Discussion: Pilsbry and Olsson (1941) described two new species of *Scalina* from the Pliocene of western Ecuador, as *Epitonium (Ferminoscala) eleutherium* and *E. (F.) manabianum*. Although worn, the specimen of *eleutherium* is considered to be synonymous with *Amaea (Scalina) ferminiana*, described from Point Fermin in the Gulf of California, Mexico (Recent).

Woodring (1959, p. 188) reported three small specimens of *Scalina* cf. *brunneopicta* (Dall, 1908) from the upper part of the Gatun Formation, Canal Zone, Panama, and compared them with the Ecuadorian Pliocene *A. (S.) eleutheria*, believing them to be closely related species.

Amaea (Scalina) ferminiana was reported by Olsson (1942, p. 228) as a Pliocene fossil from the Burica Peninsula in Costa Rica, and again (1964, p. 199) as a Neogene fossil from northwestern Ecuador. *Scala (Acrilla) wiegandi* Böse, 1910, a late Tertiary fossil from Tehuantepec on the Caribbean side of the peninsula, was placed in the synonymy of *A. (S.) ferminiana* by DuShane (1974, p. 55). Böse's species came from strata now considered middle Pliocene in age (Neogene foraminiferal zone N20) (Akers, 1981, p. 146). Dall (1898, p. 652-653), referring to the early collection of Spencer (1897, p. 14, 24) from the same locality, noted that "the beds were deposited in deep water, probably between one hundred and fifty and four hundred fathoms in depth, judging by analogous recent species." *Scalina pseudoleroyi* (Maury, 1925) from Jamaica was considered to be a closely related species by Woodring (1959, p. 187). It may be that, with time, all of the fossil forms in this species group will be relegated to synonymy under *A. (S.) ferminiana*.

Occurrence: Pliocene; Esmeraldas beds, TU 1397 (four specimens). Recent; Gulf of California, Mexico south to Peru, dredged in 36 to 275 m depth.

Genus STHENORYTIS Conrad, 1862

Type species: *Scalaria expansa* Conrad, 1862, by subsequent designation (deBoury, 1889); Miocene, Maryland.

Discussion: Sthenorytis first appeared in the late Eocene in the Americas and Europe. The genus survives today in the western Atlantic and eastern Pacific Ocean.

STHENORYTIS TURBINUS (Dall, 1908)
Figures 4, 5

Epitonium (Sthenorhytis) turbinum DALL, 1908, p. 317, pl. 9, figs, 5, 6, 8; KEEN, 1971, p. 436, fig. 665.
Epitonium (Sthenorytis) toroense DALL, 1912, p. 6; DALL, 1925, p. 27, pl. 19, fig. 5.
Epitonium toroense var. *insigne* DALL, 1912, p. 7.
Sthenorytis toroensis toroensis (Dall). WOODRING, 1959, p. 184, pl. 37, figs. 2, 3, 11, 12.
Sthenorytis toroensis euthynta WOODRING, 1959, p. 185, pl. 37, figs. 1, 4, 5, 8.
Epitonium (Sthenorytis) turbinum Dall. DUSHANE, 1974, p. 45, figs. 113-117, 160.

Diagnosis: Shell large, thick, heavy, turbinate; nuclear whorls nearly always eroded; post-nuclear whorls nine, continuous, rapidly enlarging, showing incremental growth lines and a faint basal disk; interlamellar spaces with more or less distinct low, irregularly spaced spiral bands and microscopic spiral striae; costae 9 to 12, sharp edged, wider where they attach to the whorl, with a spine at the tip; each costa flat-

tens as it approaches the suture, but adheres to the costa immediately above, with a spur that extends to the costa immediately to the left, leaving a pit at the suture, broadly reflected on the base, fusing with the lip; suture deep; aperture round, very oblique; lip heavy, reflected, continuous, with a spine on the shoulder.

Discussion: Woodring (1959, p. 184) placed *Sthenorytis toroensis* var. *insigne* (Dall, 1912) in synonymy with *S. pernobilis* (Fischer and Bernardi, 1857). Dall's type came from the Toro Limestone Member of the Chagres Sandstone at Toro Point on the Caribbean side of the Canal Zone and Woodring (1959, p. 184) subsequently obtained two fragments of a *Sthenorytis* from the same locality, basing his synonymy on these two specimens he deemed to be *S. pernobilis*. There is no figure of Dall's *S. toroensis* var. *insigne*; therefore, Woodring must have compared his two fragments with Dall's holotype (USMN 214346) and arrived at the conclusion that his and Dall's specimens represented the same taxon. With only the lower portion of the body whorl from which to make a judment, one can only take the Woodring assessment and accept his decision.

Woodring (1959, p. 184 pl. 37, figs. 2, 3, 11, 12) discussed and figured *S. toroensis toroensis* (Dall, 1912) from the Pliocene of the Canal Zone of Panama, and suggested that it might be a subspecies of *S. pernobilis*, a statement with which I do not concur. Even though the Dall species is from the Caribbean side of Panama, it is more like *S. turbinus* (Dall, 1908) from the eastern Pacific, with a turbinate outline and fewer costae (eight), than *S. pernobilis*, which has an acuminate outline and usually 12 costae. DuShane (1974, p. 47) placed *S. toroensis* in synonymy with *S. turbinus*.

Woodring (1959, p. 185) also described a new subspecies, *S. toroensis euthynta*, from the lower Pliocene Chagres Sandstone on the Caribbean coast between Rio Chagres and Pina, Canal Zone, and compared it with the nominate species. Woodring's two specimens were distinguished by their larger size and higher, narrower, less flattened lamellae, and fewer costae (eight). Woodring's (1959, pl. 37, figs. 1, 4, 5, 8) figures show *euthynta* to be conspecific with *S. turbinus*, even though the specimens are from the Caribbean. Nominal subspecies and varieties from the Pliocene of Panama and the Canal Zone exhibit a great deal of overlap in physical characteristics at different locations.

Sthenorytis toroensis euthynta does not compare well with *S. pernobilis* as the eight high costae are spaced farther apart, are bent backward with an erect shoulder hook, and have an entire aperture with a small hook.

Occurrence: Pliocene; Esmeraldas beds, TU 1397 (four specimens), TU 1398 (two specimens), and TU 1399 (two specimens). Recent; Cabo San Lucas, Baja California Sur, Mexico, to the Galápagos Islands, Ecuador, dredged in 110 to 550 m depth.

STHENORYTIS DIANAE (Hinds, 1844)
Figures 6-9

Scalaria Diana HINDS, 1844a, p. 125, figured; HINDS, 1844b, p. 125, figured; HINDS, 1844-45, p. 48, figured.

Sthenorytis paradisi HERTLEIN and STRONG, 1951, p. 90, pl. 3, fig. 5.

Sthenorytis hertleini OLSSON, 1964, p. 199, pl. 33, fig. 1, 1a, 1b.

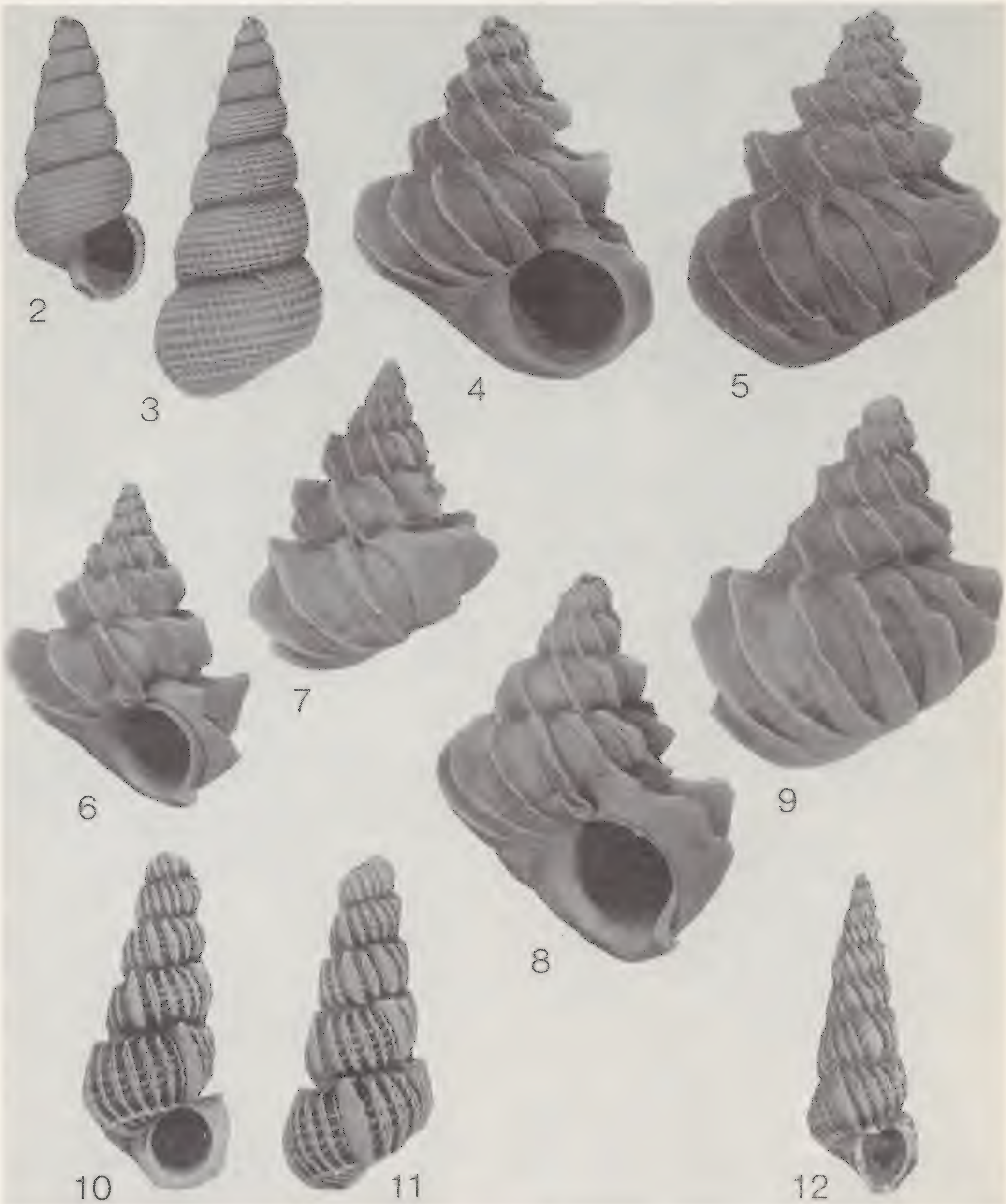
Epitonium (Sthenorytis) dianae (Hinds). KEEN, 1971, p. 434, fig. 664.

Figures 2, 3. *Amaea (Scalina) ferminiana* (Dall), TU 1397. 2, LACMIP 7630, length (L), 16.2 mm, width (W), 7.5 mm; 3, LACMIP 7631, L 23.7 mm, W 11.2 mm.

Figures 4, 5. *Sthenorytis turbinus* (Dall), TU 1397. LACMIP 7582, L 31.1 mm, W 25.8 mm.

Figures 6, 7, 8, 9. *Sthenorytis dianae* (Hinds), TU 1399. 6, 7, LACMIP 7583, L 20.4 mm, W 16.0 mm; 8, 9, LACMIP 7584, L 24.5 mm, W 19.3 mm.

Figures 10, 11, 12. *Cirsotrema togatum* (Hertlein and Strong). 10, 11, LACMIP 7585, TU 1397, L 20.1 mm, W 9.3 mm; 12, CAS 611981.01 from Quebrada Camarones (W. D. Pitt collection), L 19.5 mm, W 7.0 mm.



FIGURES 2-12

Sthenorytis dianae (Hinds). DUSHANE, 1974, p. 44, figs. 118-121.

Diagnosis: Shell size normal for *Sthenorytis*, solid; nuclear whorls unknown; post-nuclear whorls six, well-rounded, rapidly enlarging; suture deep; costae six to ten, erect on early whorls, slighly reflected on later whorls, broadly expanded, forming coronating points, thick, heavy, with axial growth striations on the faces, confluent near the aperture; basal disk faintly developed; aperture round, not entire, produced at the shoulder into a large wing.

Discussion: Olsson (1964) reported four species of *Sthenorytis* from the Neogene of northwestern Ecuador: *S. turbina* (Dall), *S. dianae* (Hinds), *S. paradisi* (Hertlein and Strong), and *S. hertleini* Olsson. The last two were synonymized by DuShane (1974) under *S. dianae*, the only species of *Sthenorytis* with a long wing-like protuberance from the aperture; all three species synonymized by DuShane have this distinctive characteristic.

Occurrence: Pliocene; Esmeraldas beds, TU 1397 (six specimens), TU 1399 (one specimen). Recent; Cabo San Lucas, Baja California Sur, Mexico, to Costa Rica, and Ecuador, dredged in 65 to 146 m depth.

Genus CIRSOTREMA Mörch, 1852

Type species: *Scalaria varicosa* Lamarck, 1822, by monotypy. Recent, western Pacific Ocean.

CIRSOTREMA TOGATUM (Hertlein and Strong, 1951) Figures 10-12

Epitonium (Cirsotrema) togatum HERTLEIN and STRONG, 1951, p. 89, pl. 3, figs. 1-5; KEEN, 1971, p. 428, fig. 633.

Cirsotrema togatum (Hertlein and Strong). DUSHANE, 1974, p. 47, figs. 54-55; PITT, 1981, p. 155, figs. 2-3.

Diagnosis: Shell large in size; nuclear whorls one and one half, showing early sculpture; third whorl post-nuclear with strong axial ribs and evenly spaced spiral sculpture; four whorls showing sufficient expansion of the ribs to join the expansion of the neighboring ribs, leaving small openings through which the regular shell surface may be seen; lamination of the ribs extending above and below to give a three-dimensional quality to the intricate sculpture; this pattern continues on all later whorls, increasing in strength with each whorl; whorls 9.5 to 10.5; suture very deep; umbilicus lacking; with a basal ridge, above and below which there are rather deep pits; aperture circular; lip slightly patulous, crenulated, thickened by the last rib.

Discussion: Pitt (1981, p. 155) reported the first fossil specimen of *Cirsotrema togatum* from the Esmeraldas Formation at Quebrada Camarones, *i.e.*, the canyon of Estero Camarones (Figure 1). A single specimen (Figure 12) was taken at that time, but more specimens have been collected subsequently (W. D. Pitt, pers. commun.).

Occurrence: Pliocene; Esmeraldas beds, TU 1397 (four specimens). Recent; Guaymas, Sonora, Mexico, throughout the Gulf of California, to Costa Rica, and the Galápagos Islands, Ecuador, dredged in 32 to 113 m depth.

LOCALITY DATA

The following Tulane University (TU) fossil localities are all from the Pliocene Esmeraldas beds exposed in Esmeraldas Province on the northwestern coast of Ecuador (see Figure 1 for index map), collected by E. H. Vokes and H. E. Vokes, January 1981.

TU 1397. Quebrada Camarones, cut bank on east side of canyon at east edge of village of Camarones, 20 km (by road) east of bridge over Rio Esmeraldas, and approximately 10 km east of mouth of Rio Esmeraldas. The exposure represents a shallow-water gravity flow into deep water.

TU 1398. Roadcut at mouth of Quebrada Camarones, east side of bridge over Estero Camarones, village of Camarones. The exposure represents mixed deep-water and shallow-water gravity flows.

TU 1399. Roadcut along sea cliff approximately 0.5 km west of Estero Camarones on west side of village of Camarones. Exposure represents a shallow-water gravity slide with gravel and wood, into deep-water clays.

LITERATURE CITED

ADAMS, HENRY, and ARTHUR ADAMS, 1856 [1853-1858], The genera of Recent Mollusca; arranged according to their organization: London (John van Voorst) 1: xi + 484 p.; 2: 661 p.; 3: 138 pls.

AKERS, W. H., 1981, Planktic foraminifera and calcareous nannoplankton biostratigraphy of the Neogene of Mexico. Addendum to Part I – Some additional mid-Pliocene localities and further discussion on the Agueguexquite and

Concepcion Superior beds: Tulane Stud. Geol. Paleontol. 16(4): 145-148, fig.1.

BÖSE, E., 1910, Zur jungtertiären Fauna von Tehuantepec. I. Stratigraphie, Beschreibung and Vergleich mit Amerikanischen Tertiärfaunen: Jahrb. K.-K. Geol. Reichsanstalt 60: 215-255, pl. 12.

BOURY, E. A. de, 1889, Revision des Scalidae Miocenes et Pliocenes de l'Italie: Bull. Soc. Malac. Ital. 14: 161-326, pl. 4.

BOURY, E. A. de, 1910 [1911], Etude sur les sous-genres de Scalidae, vivants et fossiles: Jour. Conchy. 58: 212-263, 2 pls., 4 figs.

BRISTOW, C. R., 1976, The Daule Group, Ecuador (Middle Miocene-Pliocene): Newsl. Stratigr. 5(2/3): 190-200, figs. 1-2.

CONRAD, T. A., 1862, Catalogue of the Miocene shells of the Atlantic slope: Proc. Acad. Nat. Sci. Phila. 2(8): 559-582.

CONRAD, T. A., 1865, Catalogue of the Eocene and Oligocene Testacea of the United States: Amer. Jour. Conchol. 1(1): 1-35.

DALL, W. H., 1898, Contributions to the Tertiary fauna of Florida with special reference to the Miocene Silex beds of Tampa and the Pliocene beds of the Caloosahatchie River . . . Part IV: Trans. Wagner Free Inst. Sci. Phila. 3(4): viii + 571-947, pls. 23-35.

DALL, W. H., 1908, Reports on the dredging operations off the west coast of Central America to the Galapagos, to the west coast of Mexico, and in the Gulf of California, in charge of Alexander Agassiz, carried on by the U.S. Fish Commission steamer *"Albatross"* during 1891 . . . XXXVII. Reports on the scientific results of the expedition to the eastern tropical Pacific, . . . XIV. The Mollusca and the Brachiopoda: Bull. Mus. Compar. Zool. Harvard Univ. 43(6): 205-487, pls. 1-22.

DALL, W. H., 1912, New species of fossil shells from Panama and Costa Rica collected by D. F. MacDonald: Smithson. Misc. Coll. 59(2): 1-10.

DALL, W. H., 1925, Illustrations of unfigured types of shells in the collection of the United States National Museum: Proc. U.S. Natl. Mus. 66(17): 1-41, pls. 1-36.

DUSHANE, HELEN, 1974, The Panamic-Galapagan Epitoniidae: Veliger 16(suppl.): 83 p., 5 figs., 15 pls.

DUSHANE, HELEN, 1979, The family Epitoniidae (Mollusca: Gastropoda) in the northeastern Pacific: Veliger 22(2): 91-134, 3 figs., 6 pls.

FISCHER, P. H., and M. BERNARDI, 1857, Descriptions d'especes nouvelles: Jour. Conchyl. (ser. 2) 5: 292-300.

HAMAN, DREW, and BARRY KOHL, 1986, Early Pliocene *Montfortella* (Foraminiferida) from Ecuador: Tulane Stud. Geol. Paleontol. 19(4): 181-183, pl. 1.

HASSON, P. F., and A. G. FISCHER, 1986, Observations on the Neogene of northwestern Ecuador: Micropaleontology 32(1): 32-42, fig. 1, pl. 1.

HERTLEIN, L. G., and A. M. STRONG, 1951, Eastern Pacific expeditions of the New York Zoological Society 43. Mollusks from the west coast of Mexico and Central America X: Zoologica 36(2): 67-120, pls. 1-11.

HINDS, R. B., 1844a, Description of some new species of *Scalaria* and *Murex* from the collection of Sir Edward Belcher, C.B.: Ann. Mag. Nat. Hist. (for 1843): 124-129.

HINDS, R. B., 1844b, Descriptions of some new species of *Scalaria* and *Murex* from the collection of Sir Edward Belcher, C. B.: Proc. Zool. Soc. London (1843) 11: 123-146.

HINDS, R. B., 1844-1845, The zoology of the voyage of H. M. S. *Sulphur* under the command of Capt. Sir Edward Belcher...during 1836-1842, 2 [Mollusca]: London, Smith Elder and Co., 72 p., 21 pls. [Collation: Hertlein and Strong, 1955: Part 1, p. 1-24, pls. 1-7 (July 1844); Part 2, p. 25-48, pls. 8-14 (Oct. 1844); Part 3, p. 49-72, pls. 15-21 (Jan. 1845).]

KEEN, A. M., 1971, Sea shells of tropical west America, marine mollusks from Baja California to Peru. Second Edition. Stanford University Press, Stanford, California. xiv + 1064 p., 22 color plates, ca. 4000 figures, 6 maps.

LAMARCK, J. B. P. A. de M. de, 1822, Histoire naturelle des Animaux sans vertebres. Vol. 6, pt. 2, 232 p. [Scalaires, p. 226-229].

MAURY, C. J., 1925, A further contribution to the paleontology of Trinidad (Miocene horizons): Bulls. Amer. Paleontol. 10(42): 1-250, 43 pls.

MELVILL, J. C., 1897, Description of thirty-four species of marine mollusks from the Arabian Sea, Persian Gulf and Gulf of Oman: Mem. Proc. Manchester Lit. Philos. Soc. 41(3): 25 p., 2 pls.

MÖRCH, O. A. L., 1852-1853, Catalogus conchyliorum quae relinquit D. Alphonso D'Aguirra et Gadea Comes de Yoldi: Copenhagen, fasc. 1 [Gastropoda, etc.], 170 p.

OLSSON, A. A., 1942, Tertiary and Quaternary fossils from the Burica Peninsula of Panama and Costa Rica: Bulls. Amer. Paleontol. 27(106): 153-258, pls. 14-25.

OLSSON, A. A., 1964, Neogene mollusks from northwestern Ecuador: Paleontol. Res. Inst., Ithaca, 256 p., 38 pls.

PALMER, K. V. W., 1937, The Claibornian Scaphopoda, Gastropoda, and dibranchiate Cephalopoda of the southern United States: Bulls. Amer. Paleontol. 7(32): 730 p., 90 pls.

PILSBRY, H. A, and A. A. OLSSON, A Pliocene fauna from western Ecuador: Proc. Acad. Nat. Sci. Phila. 93: 1-79, pls. 1-19.

PITT, W. D., 1981, Two new gastropod occurrences in the Ecuadorian Neogene: Tulane Stud. Geol. Paleontol. 16(4): 155-156, figs. 1-3.

SOWERBY [II], G. B., 1844, Thesaurus Conchyliorum, or monograph of genera of shells, edited by G. B. Sowerby, Jr., completed by G. B. Sowerby [III]: London, vol. 1, pt. 4 *Scalaria*, p. 83-146, pls. 32-40.

SPENCER, J. W., 1897, Great changes of sea level in Mexico and the interoceanic connections: Bull. Geol. Soc. Amer. 9: 13-34, 6 figs., pls. 1-5.

VOKES, E. H., 1988, Muricidae (Mollusca: Gastropoda) of the Esmeraldas beds, northwestern Ecuador: Tulane Stud. Geol. Paleontol. 21(1):1-50, pls. 1-6, text-figs 1-14.

WILLETT, GEORGE, 1939, A new species of mollusk from the San Pedro Pleistocene: Bull. So. California Acad. Sci. 38(3): 202-203, p. 54.

WOODRING, W. P., 1959, Geology and paleontology of Canal Zone and adjoining parts of Panama. Description of Tertiary mollusks (Gastropods: Vermetidae to Thaididae): U. S. Geol. Surv., Prof. Paper 306-B: 147-239, pls. 24-38.

July 20, 1988

REVIEWS

THE UTILITY OF REGIONAL GRAVITY AND MAGNETIC ANOMALY MAPS, edited by W. J. Hinze. Published by the Society of Exploration Geophysicists, Tulsa, Oklahoma, 1985, xiv + 454 pp., color illustrations, index, $75.00

This volume presents thirty-three papers by more than fifty authors representing the remarkable body of scientific information gained from recent compilation of gravity and magnetic anomaly maps. The subjects included range from map preparation to the multitudinous uses of regional maps illustrated with actual examples from mineral and geothermal exploration, earthquake-hazard evaluation, general geologic mapping, and the exploration for petroleum. Digital processing, digital filtering, and data-enhancement techniques applied to gravity and magnetic data are extensively treated. The application of geophysical techniques to determine the nature of the basement rock beneath the cover of sedimentary and surficial deposits is stressed to provide an improved knowledge of the Earth's crust. The volume begins with five large composite magnetic and gravity anomaly maps of the United States and Canada in full color. Throughout the work the map coverage ranges from regional to national; most maps are of North America but global maps and maps of other continents are included. This volume will constitute a major reference source for gravity and magnetic maps of the Earth for many years to come.

THE FACTS ON FILE DICTIONARY OF GEOLOGY AND GEOPHYSICS, by Dorothy Farris Lapidus and Donald R. Coates, scientific adviser. Published by Facts On File Publications, New York and Oxford, 1987, iv + 347 pp., $24.95

This is an alphabetical self-indexing reference tool to the basic terminology of geology and geophysics for the student, the amateur, and professional scientists in related fields. It is clear and concise and quite useful. The more than three thousand terms and phrases included appear to provide thorough and comprehensive coverage. The listings are enhanced by about seventy-five explanatory line drawings. This volume extends the Facts On File series; previously dictionaries on Biology, Botany, Chemistry, Mathematics, Physics, and Science have been published. The Geology and Geophysics volume is recommended as a general reference for students and nonspecialists.

—H.C.S.

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 21, Number 2 July 20, 1988

AGE AND STRATIGRAPHIC CORRELATION OF THE RAYSOR FORMATION, LATE PLIOCENE, SOUTH CAROLINA

LAUCK W. WARD

U. S. GEOLOGICAL SURVEY
RESTON, VIRGINIA

AND

PAUL F. HUDDLESTUN

GEORGIA GEOLOGIC SURVEY
ATLANTA, GEORGIA

CONTENTS

Page

I. ABSTRACT 59
II. INTRODUCTION 59
III. HISTORY OF THE TERM RAYSOR FORMATION 61
IV. PREVIOUS CORRELATION OF THE RAYSOR FORMATION 61
V. STUDY MATERIAL 63
VI. MOLLUSCAN ANALYSIS 65
VII. FORAMINIFERAL ANALYSIS 72
VIII. SUMMARY 73
IX. ACKNOWLEDGMENTS 73
X. REFERENCES CITED 73
XI. APPENDIX 74

I. ABSTRACT

Mollusks and foraminifers from the type section of the Raysor Formation in the Coastal Plain of South Carolina were obtained from collections in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., and the Charleston Museum, Charleston, South Carolina. Analysis of the molluscan taxa shows the unit to be correlative with the Rushmere and Morgarts Beach Members of the Yorktown Formation in Virginia and North Carolina. Planktic foraminifers in the Raysor indicate an equivalency with Blow's (1969) Zone N20 [= Berggren, *et al.* (1983) Zone PL3]; this equivalency would suggest that the unit is lower upper Pliocene. The Raysor was deposited on a shallow shelf in a setting that was temperate at first, but which quickly warmed to subtropical.

II. INTRODUCTION

The Raysor Formation, a lithic unit in the Upper Tertiary of South Carolina, has been correlated with various beds of the Yorktown and former Duplin formations in Virginia, North Carolina, and South Carolina (Cooke, 1936; Blackwelder and Ward, 1979; Campbell *et al.*, 1975). The Duplin is now incorporated in the Raysor and Yorktown formations (Blackwelder and Ward, 1979). Some uncertainty exists concerning the exact stratigraphic placement of the Raysor because of the presence of temperate molluscan taxa that give it a lower Yorktown character, even though the preponderance of species present indicates correlation with the upper Yorktown. Collections of mollusks from the original Raysors Bridge locality (chosen by Cooke, 1936, p. 116, to be the type section, see figure 1) were obtained from the Char-

EDITORIAL COMMITTEE FOR THIS PAPER;
LYLE D. CAMPBELL, University of South Carolina at Spartenburg, South Carolina
JULES R. DUBAR, Bureau of Economic Geology, University of Texas, Austin, Texas
WALLACE C. FALLAW, Furman University, Greenville, South Carolina

Figure 1. Index map of South Carolina showing the following localities referred to in the text. (1) Raysors Bridge, (2) Canadys Bridge, (3) mouth of Four Hole Swamp, (4) Neostratotype section of the Raysor Formation, (5) Givhans Ferry, (6) Goose Creek, (7) Martin Marietta, Berkeley Quarry, (8) Tearcoat Branch, (9) "Muldrow Place" of Gardner and Aldrich (1919).

leston Museum, Charleston, South Carolina, and the National Museum of Natural History, Smithsonian Institution, Washington, D.C. Some of the specimens retained enough matrix for a foraminiferal analysis.

III. HISTORY OF THE TERM RAYSOR FORMATION

Cooke (1936, p. 115) proposed the term "Raysor marl" for "deposits of upper Miocene age older than the Duplin marl in South Carolina." Thus, the formation name was based on a perceived difference in age and not based on lithic characteristics. Cooke (1936, p. 116) based his descripton on that of Sloan (1908, p. 280-281) and added no information on the outcrop on the Edisto River, "one-fourth of a mile below [Raysors] Bridge on west side, 8 miles S. 25° W. of St. Georges," Colleton County, South Carolina (fig. 1). Records of the mollusk collections in the National Museum of Natural History indicate that Earle Sloan and Frank Burns, an assistant to W. H. Dall (U. S. Geological Survey), visited the Raysors Bridge locality in 1904 (USGS Tertiary loc. 3991). Burns made another very small collection in 1904 at the confluence of Four Hole Swamp with the Edisto River, Dorchester County, S.C. (USGS Tertiary loc. 3989; fig. 1). Sloan made a larger collection in 1909, and sent specimens from that collection to the U. S. National Museum (USGS 5295). The bulk of the 1909 collection is retained in the Charleston Museum, where most of Sloan's collections are kept (Blackwelder, 1967).

The Raysors Bridge exposure has not been relocated since the Sloan collection in 1909. Sloan (1908, p. 280-281) described a section at that locality (his loc. no. 366). Cooke (1936, p. 116) repeated the section with some modifications as follows:

	Feet
Wicomico formation (Pleistocene):	
5. Mottled clay and sand	15
4. Dun-colored clay in layers, horizontally interstratified with thin seams of sand	11
3. Coarse sand on the much-eroded surface of the Raysor marl . . .	3
Raysor marl (upper Miocene)	
2. Marl consisting of shells in a dark-blue soft matrix; contains 80.82 percent of calcium carbonate	3¼
Cooper marl (Eocene):	
1. Harsh, hard glauconitic marl similar to marl at Stokes Bridge .	2

Attempts by the authors to find the original locality have failed. Possibly the locality can only be seen at extremely low water or, it may be slumped and overgrown. In 1975 Ward drilled an auger hole just south of the Route 15 bridge over the Edisto River at Canadys, Colleton County (fig. 1, loc. 2). He pentrated 13.5 feet (4.1 m) of fine, shelly, calcareous sand similar to that described by Sloan.

Cooke (1936) and Blackwelder and Ward (1979) recognized the "middle Yorktown" (of Mansfield, 1928, 1944) equivalency of the Raysor collections at the National Museum (USNM 5295, USNM 3991). Blackwelder and Ward (1979) further recognized that, in its type area, the Raysor was highly calcareous and was relatively lacking in clastic material. They suggested, therefore, that the name Raysor Marl (emended to Raysor Formation) be retained as a unit of formational rank and a facies equivalent of the shelly quartzose sands of the Yorktown Formation (fig. 2). The Yorktown, in its strict lithic sense, extends from Virginia across North Carolina and into South Carolina. In Virginia and North Carolina, the unit was deposited as a series of shelly sands and silty sands across the entire basin. In South Carolina, these clastic deposits became thinner southward, and were deposited only very near shore. Seaward in the basin, calcarenitic material dominates and replaces the clastic component. This predominatly calcareous facies is called the Raysor Formation.

Because the original type section could not be located, Blackwelder and Ward (1979, p. 39) selected a neostratotype section for the Raysor Formation on the left bank of the Edisto River, 0.68 miles (1.1 km) upriver of the Route 61 bridge, Dorchester County, S.C. (fig. 1, loc. 4).

IV. PREVIOUS CORRELATION OF THE RAYSOR FORMATION

Tuomey and Holmes (1855) did not study the beds near Raysors Bridge but discussed equivalent beds at Givhans Ferry

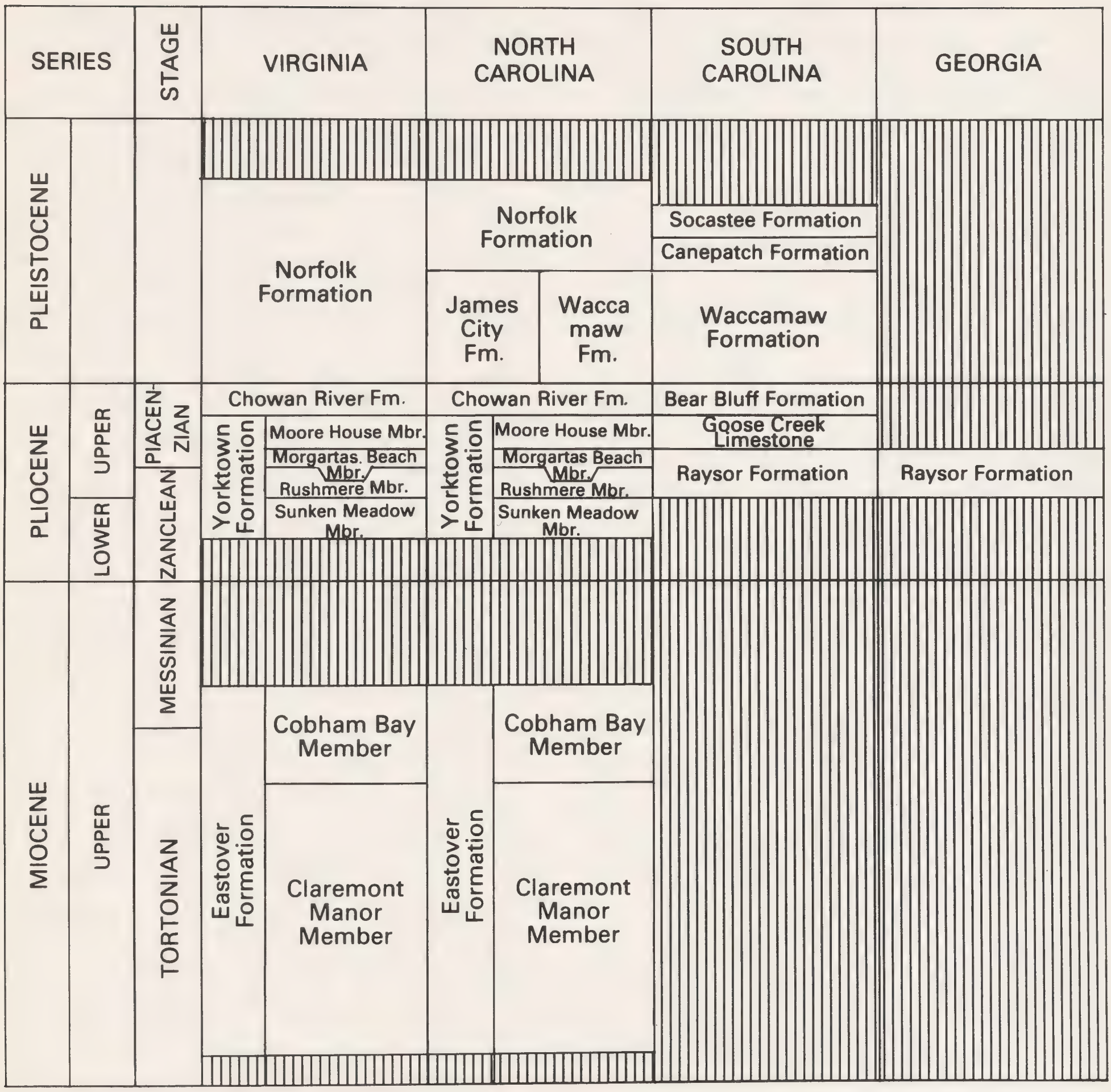


Figure 2. Correlation chart showing Neogene units from Virginia to Georgia.

(fig. 1, loc. 5). They concluded that those beds were of Pliocene age. Sloan (1908, p. 281) reported that the shelly marl below Raysors Bridge was of Miocene age. Sloan, who was not a paleontologist, may have been given this information by Frank Burns, (USGS), who helped him make his first collections in 1904 (USGS coll. no. 3991). Mansfield (1935), in a correlation chart, indicated that the bed at Raysors Bridge was equivalent to this "Zone 1" of the Yorktown Formation in Virginia and placed it in the lower upper Miocene. Cooke (1936, p. 115-117), referring to the lists of mollusks identified by W. C. Mansfield (USGS) from the Sloan collections, concluded that the Raysor deposits were of "upper Miocene age" and "older than the Duplin marl in South Carolina." Cooke further stated that the Raysor was believed to be "equivalent to a middle part of the Yorktown formation of Virginia and North Carolina and to the *Ecphora* zone of the Choctawhatchee Formation of Florida." Cooke's (1936, p. 100) correlation chart, however, showed that the Raysor was the equivalent of the lower and middle Yorktown Formation. Mansfield (1944) placed the Raysor in the lower Yorktown (his "Zone 1"), even though his zonal indi-

cator "*Pecten clintonius*" is not present in the unit. The Yorktown and its equivalents have been included in the Miocene, but Hazel (1971, p. 8) concluded that beds from the *Ecphora* zone at Alum Bluff, Florida, were in part early Pliocene and suggested that the "upper Miocene-lower Pliocene boundary in the Atlantic and Gulf Coastal Plain eventually will be revised further downward to include in the Pliocene more of the deposits that have been traditionally assigned to the upper Miocene." Hazel (1977, 1983) subsequenty placed all of the Yorktown, as applied in the strict sense by Ward and Blackwelder, 1980, and its equivalents in the Pliocene. The Raysor, therefore, has since been considered to be Pliocene (Blackwelder and Ward, 1979; Cronin, 1981; Cronin, *et al.*, 1984).

The correlation of the Raysor with specific units of the Yorktown Formation has been ambiguous. Campbell *et al.*, (1975) suggested that the "Raysors Bridge Member" (his term) was equivalent to Zone 1 of the Yorktown Formation (of Mansfield, 1928, 1935, 1944) but stated that the data were not conclusive. Blackwelder and Ward (1979) indicated a middle Yorktown equivalency based on the presence of the following mollusks (USGS loc. no. 5295):

Fissuridea redimicula (Say, 1824)
(= *Diodora redimicula* in Table 1)
Glycymeris subovata (Say, 1824)
Crassatella undulata Say, 1824
Anadara lienosa (Say, 1832)

This correlation would mean equivalency with the Rushmere and Morgarts Beach Members of the Yorktown Formation of Ward and Blackwelder (1980). Cronin (1981, p. 817) stated that the planktic foraminifers in the Raysor Formation "indicate the probable time-equivalence of this ostracode zone with the *Pterygocythereis inexpectata* and lower part of the *Orionina vaughani* ostracode Assemblage Zones of the Yorktown Formation of Virginia." These zones were established by Hazel (1971) and are equivalent to the lower (Zone 1 of Mansfield 1928, 1944) and upper (Zone 2 of Mansfield) parts of the formation. Hazel (1983) and Cronin *et al.* (1984) reiterated this placement. Because of the ambiguity in correlating the Raysor, the present study was initiated. All known collections from the original Raysors Bridge locality made by Sloan and(or) Burns were examined, and these collections then were compared with others made in South Caroina, North Carolina, and Virginia.

V. STUDY MATERIAL

The principal components of this study are three USGS collections in the National Museum of Natural History, Washington, D.C., and one collection in the Charleston Museum, Charleston, S.C., which contain a total of 492 mollusk specimens. These collections were made by Earle Sloan and Frank Burns in 1904 and by Sloan in 1909. The USGS collections 5295 and 3991 are listed as being from Raysors Bridge but clearly come from the locality described by Sloan (1908, p. 280-281) "one-fourth of a mile below [Raysors] Bridge on [the] west side," Colleton County, South Carolina. Sloan's collection in the Charleston Museum also lists Raysors Bridge as the locality but his locality number (S.C. Survey no. 366) is the same locality as the one described in 1908 (p. 280). Another sample was located that contained the single oyster species *Ostrea locklini*. The occurrence of that species in the sample suggests the presence of the same bed (Raysor Formation) at least as far downriver as the mouth of Four Hole Swamp, which is located approximately one mile (1.85 km) upriver from the neostratotype section chosen for the Raysor by Blackwelder and Ward (1979).

Taxa from each of the four collections are listed in Table 1. The number of specimens and their condition, if less than satisfactory, also are given. Comments on selected specimens are included. Several specimens in the collections are of unknown origin because the specimens are associated with lithologies different from the bulk of the material. These specimens are noted in the Appendix.

In addition to the Sloan Raysor material, Ward's collections of mollusks from the Martin Marietta Quarry in Berkeley County (fig. 1, loc. 7) and Tearcoat Branch, Sumter County (fig. 1, loc. 8) were studied and compared with Sloan's material as was the Gardner and Aldrich (1919) collection from the "Muldrow Place" (fig. 1, loc. 9). The close similarity of the assemblages

Taxa from Raysors Bridge	MIOCENE		PLIOCENE						ADDITIONAL SOUTH CAROLINA LOCALITIES		
	MIDDLE	UPPER	LOWER	UPPER							
	ST. MARYS	EAST-OVER	YORKTOWN				CHOWAN RIVER	JAMES CITY	MARTIN MARIETTA — CROSS QUARRY	TEAR-COAT BRANCH	MULD-ROW PLACE
			SUNKEN MEADOW	RUSH-MERE	MOR-GARTS BEACH	MOORE HOUSE					
GASTROPODA											
Diodora redimicula (Say)				•	•	•			•	•	•
Turritella sp. new				•	•				•		
Polinices duplicatus (Say)	•	•	•	•	•	•	•	•			
Petaloconchus sculpturata H.C. Lea				•	•	•	•			•	•
SCAPHOPODA											
Dentalium attenuatum Say	•	•	•	•	•	•	•		•	•	•
Cadulus thallus (Conrad)	•	•	•	•	•	•	•	?	•	•	•
BIVALVIA											
Nucula proxima Say	•	•	•	•	•	•	•	•	•	•	•
Nucula taphria	•	•	•	•	•	•	•	•		•	•
Yoldia laevis (Say)	•	•	•	•	•	•	•	•			•
Nuculana sp. near *N. concentrica* (Say)	•	•	•	•	•	•	•	•	•		
Nuculana sp.				•	•	•	•	•			
Anadara lienosa (Say)				•	•	•	•		•	•	•
Glycymeris subovata tuomeyi Dall				•	•	•	•			•	•
Carolinapecten eboreus (Conrad)				•	•	•	•	•			•
"*Leptopecten*" *irremotis* Olsson and Harbison				•	•	•	•	•			
Amusium mortoni (Ravenel)				•	•				•		
Chesapecten sp. nearest *C. jeffersonius* (Say)			?	?							
Chesapecten septenarius (Say)				•	•						
Chesapecten madisonius (Say)				•	•	•	•		•		
Pteria sp.				•	•	•	•		•		
Plicatula marginata Say				•	•	•	•	•	•	•	•
Ostrea locklini Gardner				•	•						
Ostrea raveneliana Tuomey and Holmes				•	•	•	•		•	•	•
Lucinoma contracta (Say)	•	•	•	•	•	•	•	•			
Lucinisca cribrarius (Say)				•	•	•	•		•	•	•
Parvilucina multilineata (Tuomey and Holmes)				•	•	•	•	•	•	•	•
Callucina keenae Chavan				•	•	•	•	•	•	•	•
Divaricella quadrisulcata (d'Orbigny)			•	•	•	•	•	•		•	•
Diplodonta sp.											
Diplodonta yorkensis Dall				•	•	•	•				
Pseudochama corticosa (Conrad)				•	•	•	•			•	•
Echinochama arcinella (Linné)									•		
Aligena aequata Conrad				•	•	•	•				•
Carditamera arata (Conrad)				•	•	•	•	•		•	•
Cyclocardia granulata (Say)	•	•	•	•	•	•	•	•	•	•	•
Astrate concentrica Conrad				•	•	•	•	•	•	•	•
Astarte floridana Dall											
Astarte sp.									•		
"*Crassatella*" *gibbesii* (Tuomey and Holmes)									•		
Marvacrassatella undulatus (Say)				•	•	•	•		•	•	•
"*Cardium*" sp.				•	•	•	•				
Tellina declivis Conrad			•	•	•	•	•		•		
Tellina aequistriata (Say)				•	•	•	•	•		•	•
Semele subovata (Say)				•	•	•	•		•	•	
Semele sp.		•	•	•	•	•	•				
Glossus fraterna (Say)			•	•	•	•	•				
Dosinia acetabulum (Conrad)	•	•	•	•	•	•	•		•		
Pitar sayana (Conrad)	•	•	•	•	•	•	•		•	•	•
Lirophora sp. prob. *L. athleta* (Conrad)				•	•	•	•		•	•	•
Caryocorbula inaequalis (Say)	•	•	•	•	•	•	•		•		•
Caryocorbula sp.											
Varicorbula sp.											
Hiatella arctica (Linné)	•	•	•	•	•	•	•	•		•	•
Kuphus fistula (H.C. Lea)			•	•	•	•	•				
Pandora arenosa Conrad	•	•	•	•	•	•	•	•		•	•

Table 1. Composite list of taxa from 4 collections from the Raysor Formation in its type area. Distribution of the taxa in the Miocene and Pliocene is plotted.

suggest that the beds at those localities are Raysor equivalents.

Comments on collection from USGS locality 5295. Mansfield studied this collection and Cooke (1936, p. 116-117) published a list of its taxa with Mansfield's comments. That list is as follows:

Paracyathus vaughani Gane; identified by T. W. Vaughan
Epitonium sp.
Turritella variabilis Conrad
Cadulus thallus (Conrad)
Nucula proxima Say

Leda trochilia Dall (like form in *Ecphora* zone of Choctawhatchee Formation)
Yoldia tarphaeia Dall (like form in *Ecphora* zone of Choctawhatchee Formation)
Glycymeris subovata (Say) var.
Arca (Scapharca) lienosa (Say)
Ostrea sp.
Ostrea disparilis Conrad
Pecten jeffersonius Say
Pecten jeffersonius var. aff. *P. jeffersonius edgecombensis* Conrad
Plicatula marginata Say
Crassatellites gibbesii Tuomey and Holmes
Crassatellites undulatus cyclopterus Dall
Astarte concentrica var. *bella* Conrad
Astarte floridana Dall (*Ecphora* zone)
Cardita (Carditamera) arata (Conrad)
Venericardia granulata Say
Chama corticosa Conrad
Echinochama arcinella (Linnaeus)
Phacoides cribrarius (Say)
Phacoides contractus (Say)
Phacoides crenulatus Conrad
Phacoides radians (Conrad)
Diplodonta nucleiformis (Wagner)
Diplodonta yorkensis Dall?
Divaricella quadrisulcata D'Obigny
Aligena aequata (Conrad)
Cardium sp.
Isocardia fraterna Say, grading toward *I. carolina* Dall
Chione latilirata athleta Conrad
Tellina (Merisca) aequistriata Say
Tellina (Angulus) declivis Conrad
Semele subovata (Say) var.
Corbula inaequalis Say
Corbula, group of *C. chipolana* Dall
Saxicava sp.
Teredo calamus H. C. Lea

The specimen of *Paracyathus vaughani* Gane is now missing from the collection but several specimens are still present in the Sloan collection in the Charleston Museum. We have made several revisions in the taxonomic listings, but overall the lists are very similar (see Appendix). Several taxa that Cooke (1936) listed were not present in either USGS collection 5295 or 3991. Either these forms were put in the National Museum of Natural History (USNM) set and were lost, or were included in the list because they were in the Sloan collection in Charleston. Two of these taxa are "*Pecten jeffersonius* Say" and "*Pecten jeffersonius* var. aff. *P. jeffersonius edgecombensis* Conrad," as Cooke (1936, p. 116) listed.

Comments on collection from USGS locality 3991. This collection was described as coming from "1 mile below Raysor Bridge, on road from St. George station to courthouse, Earle Sloan and Frank Burns, collectors." We think that this is the same locality as USGS 5295. The collection made in 1904 is small, and its unique components probably prompted the later more extensive collections in 1909 (USGS, coll. no. 5295 and Sloan coll. no. 366 at the Charleston Museum).

Comments on collection from USGS locality 3989. This collection consists of two specimens of *Ostrea locklini* Gardner. A note in the specimen tray stated that the taxon is the same as that collected at Raysors Bridge, but the note appears to have been added later.

Comments on Sloan collection from locality 366 in Charleston Museum. Blackwelder (1967) first listed taxa from this collection. Blackwelder used the names that were written on the museum labels and made no attempt to update the taxonomic determinations. This collection is the most extensive in terms of numbers of individual specimens (308), but it contains only a few more species than the USGS 3991, 3989, and 5295 collections. The numerous specimens, however, did provide additional information on the assemblage. Furthermore, several specimens in this collection retained the original sediment in which they were deposited. This sediment was processed for foraminifers. The numbers assigned to the various taxa refer to the boxes in which they were packed in the Charleston Museum. The boxes commonly contained several specimens and, in some, many specimens.

VI. MOLLUSCAN ANALYSIS

As can be seen from Table 1, mollusks are common to abundant in the thin Pliocene bed below Raysors Bridge. Many are well preserved, and others appear water-worn. Specific comments on the various specimens in the collections are made in the Appendix. Table 1 shows the presence of only one species that is confined to beds older than the upper Pliocene Rushmere Member of the Yorktown

Formation – *Chesapecten jeffersonius* (Say, 1824) or a species closely related. *Chesapecten jeffersonius* occurs only in the lower Pliocene Sunken Meadow Member of the Yorktown Formation in Virginia, and an unconformity between that unit and the Rushmere Member represents a diastem of at least 0.5 million years. The *Chesapecten* lineage is so well represented in the Chesapeake Group of Virginia and Maryland that it is certain that faunal turnovers are due to speciation and not solely the result of migration of taxa or environmental shifts. Such speciation is evident in the *C. jeffersonius*, *C. madisonius*, and *C. septenarius* stock. *Chesapecten jeffersonius* is characterized by few and heavy ribs, finely scaled, which are square in outline at youth and become more rounded with age. In the lowest part of the Rushmere Member, two new forms appear which have affinities with *C. jeffersonius*, namely *C. madisonius* and *C. septenarius*. The earliest forms of *C. madisonius* have a few more ribs than *C. jeffersonius*, but the valves of *C. madisonius* are less inflated, and the ribs are more rounded and somewhat more coarsely scaled. *Chesapecten septenarius*, however, has fewer ribs than typical *C. jeffersonius*. In addition, *C. septenarius* has finely scaled ribs that are square in outline from juvenile to adult. Although the geographic ranges of *C. madisonius* and *C. septenarius* overlap, *C. madisonius* is common only in the upper Yorktown Formation of late Pliocene age north of the Neuse River and it is scarce to absent south of that area. *Chesapecten septenarius* is present, but never abundant, in stratigraphic equivalents of the Rushmere and Morgarts Beach members from Virginia to Florida. It appears to have been common in the type section of the Raysor and is also common at the Martin Marietta Berkeley Quarry in the Raysor Formation.

Although having several distinctly subtropical to tropical elements, the Raysor assemblage at the type locality is clearly most closely allied with the temperate fauna in the Salisbury Embayment (area of the Coastal Plain that includes parts of New Jersey, Maryland, and Virginia, and all of Delaware) to the north. An examina-

---

PLATE 1

1. *Diodora redimicula* (Say, 1824)
   Apical view of broken specimen in the Sloan Collection (box 1) at Charleston Museum, Charleston, S.C.; length 44.7 mm, height 19.3 mm.
2. *Turritella* sp.
   Apertural view of an incomplete specimen (USNM 405347) from USGS collection no. 3991 in the U. S. National Museum, Washington, D.C.; height 49.0 mm.
3. *Turritella* sp.
   Apertural view of an incomplete specimen (USNM 405348) from USGS collection no. 3991 in the U. S. National Museum, Washington, D.C.; height 28.4 mm.
4. *Glycymeris subovata tuomeyi* Dall, 1898
   Exterior view of an incomplete left valve (USNM 405349) from USGS collection no. 5295 in the U. S. National Museum, Washington, D.C.; length 53.5 mm, height 76.8 mm.
5. *Anadara lienosa* (Say, 1832)
   Exterior view of an incomplete left valve (USNM 405350) from USGS collection no. 5295 in the U. S. National Museum; Washington, D.C.; length 72.7 mm, height 46.8 mm.
6. *Ostrea locklini* Gardner, 1945
   Exterior of a left valve (USNM 405351) from USGS collection no. 5295 in the U. S. National Museum, Washington, D.C.; length 41.8 mm, height 34.5 mm.
7. *Ostrea raveneliana* Tuomey and Holmes, 1855
   Exterior of a left valve (USNM 405352) from USGS collection no. 5295 in the U.S. National Museum, Washington, D.C.; length 90.2 mm, height 96.1 mm.
8. *Pseudochama corticosa* (Conrad, 1833)
   Exterior and interior of a right valve of a specimen in the Sloan Collection (box 43) at Charleston Museum, Charleston, S.C.; length 54.1 mm, height 56.5 mm.

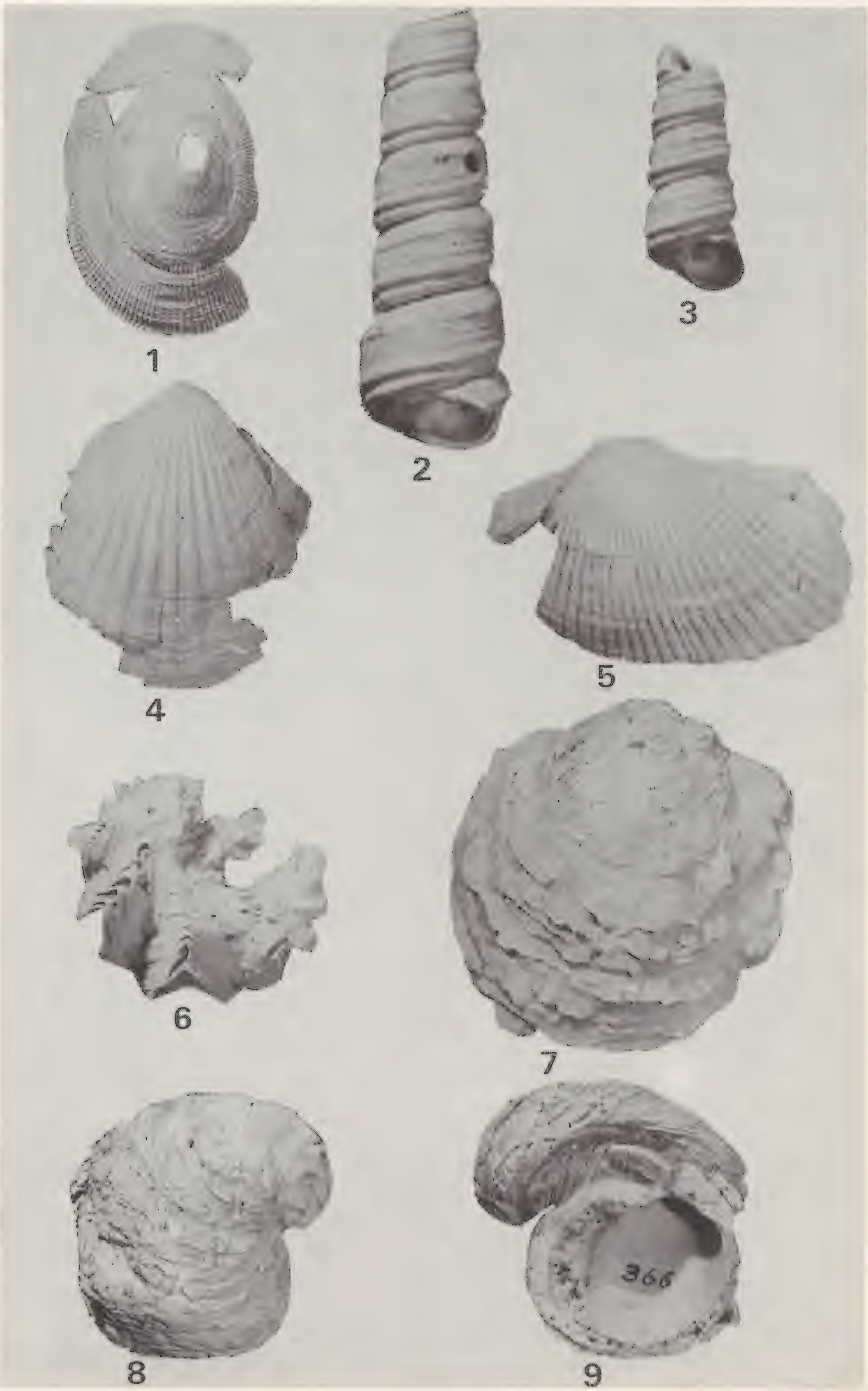


PLATE 1

tion of the assemblage as listed in Table 1 make this alliance clear, but the origin of the temperate condition is unclear. Perhaps a near-shore cool current brought temperate taxa far south of their normal range, or maybe the initial transgressive seas that invaded the area south of the Cape Fear Arch were temperate in nature. Whatever the reason, the temperate condition was succeeded by a more subtropical to tropical marine environment indicated by a principally carbonate substrate and a more diverse molluscan assemblage.

There are several possible explanations for the presence of a species in the upper Pliocene beds in South Carolina which is morphologically similar, if not identical to, *C. jeffersonius*. *Chesapecten jeffersonius* appears to have proliferated in a cool-temperate setting in the Yorktown (Sunken Meadows Member) sea and it may have survived the low sea-level cooling event, which is marked by an unconformity between the Sunken Meadows and Rushmere Members. If *C. jeffersonius* survived that regression, it may have been extant long enough to accompany the next transgression into the Charleston Embayment.

Another possibility is that an equivalent of the Sunken Meadows Member was deposited in South Carolina but later was largely removed by erosion. This possibility is plausible, as evidenced by the large shark teeth of *Procarcharodon megalodon* (Charlesworth), which are found as lag deposits over much of the South Carolina Coastal Plan. *Procarcharodon megalodon* was common in the Sunken Meadow Member and its equivalents in Virginia and North Carolina, but there is no record of the taxon in any younger units except as reworked phosphatized basal lag. Clearly an older unit, either Miocene or early Pliocene, was deposited over much of the South Carolina Coastal Plain, and this unit has been largely removed by erosion. The specimens of *Chesapecten jeffersonius* and also *Glossus fraterna* may represent a residuum of an older unit, but their good preservation makes this doubtful. Both taxa were abundant in the lower Pliocene, Sunken Meadow Member in Virginia and North Carolina, but *G. fraterna* is present also in the upper Pliocene Rushmere and Moore House Members of the Yorktown. *Glossus* has an aragonitic shell and is much less likely to survive reworking than the

---

PLATE 2

1. *Chesapecten madisonius* (Say, 1824)
   Exterior of a right valve in the Sloan Collection (box 18) at Charleston Museum, Charleston, S.C.; length 121.3 mm, height 119.4 mm. Specimen has fewer ribs than typical *C. madisonius* (Say, 1824).
2. *Chesapecten* sp. aff. *C. jeffersonius* (Say, 1824)
   Exterior of a left valve in the Sloan Collection (box 17) at Charleston Museum, Charleston, S.C.; length 86.9 mm, height 84.9 mm.

3, 4. *Chesapecten septenarius* (Say, 1824)
   3. Exterior of a right valve in the Sloan Collection (box 18) at Charleston Museum, Charleston, S.C.; length 77.2 mm, height 77 mm.
   4. Exterior of a right valve from the Sloan collection (box 19); length 136.4 mm, height 129.6 mm.

5. *Chesapecten madisonius* (Say, 1824)
   Exterior of a left valve in the Sloan Collection (box 19) at Charleston Museum, Charleston, S.C.; length 145.2 mm, height 149.5 mm.
6. *Carolinapecten eboreus* (Conrad, 1833)
   Exterior of a right valve in the Sloan Collection (box 16) at Charleston Museum, Charleston, S.C.; length 46.2 mm, height 43.2 mm.
7. *Lucinisca cribrarius* (Say, 1824)
   Exterior of a left valve (USNM 405353) from USGS collection no. 5295 in the U. S. National Museum, Washington, D.C.; length 8.7 mm, height 8.2 mm.
8. *Plicatula marginata* Say, 1824
   Exterior of a left valve (USNM 405354) from USGS collection no. 5295 in the U.S. National Museum, Washington, D.C.; length 17.5 mm, height 19.0 mm.

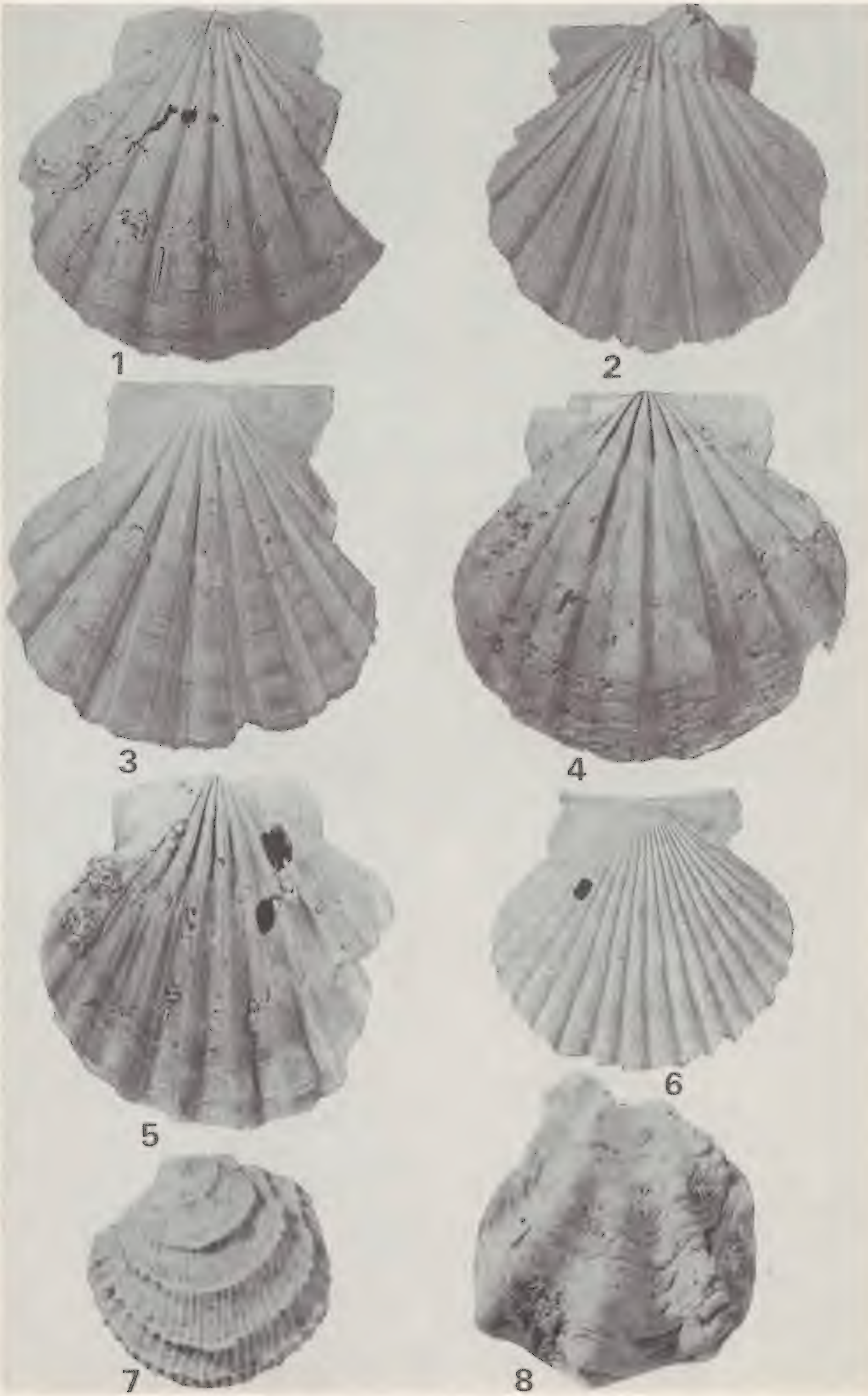


PLATE 2

calcitic pectinids. Our conclusion is that *C. jeffersonius* and other temperate forms accompanied the earliest transgression of the Raysor sea and that the taxon was soon replaced by the more subtropical to tropical species *C. septenarius*. The early temperate setting produced a mixed environment where Chesapeake mollusks occurred together with their subtropical counterparts. This early cool-water event clearly influenced the molluscan assemblage in the Jackson Bluff Formation at Alum Bluff, Florida, where a Chesapeake assemblage dominates and has an admixture of subtropical taxa.

Despite the anomalous occurrence of what appears to be a species closely related to *Chesapecten jeffersonius*, the remainder of the assemblage has a strong affinity with that of the upper Pliocene Rushmere, Morgarts Beach, and Moore House Members of the Yorktown. The following taxa are restricted to the upper Pliocene:

Turritella sp. new
Glycymeris subovata tuomeyi Dall, 1898
Chesapecten septenarius (Say, 1824)
Chesapecten madisonius (Say, 1824)
Carolinapecten eboreus (Conrad, 1833)
Astarte concentrica Conrad, 1834
Marvacrassatella undulatus (Say, 1824)
Lirophora sp. probably *L. athleta* (Conrad, 1863)

Chesapecten septenarius (Say, 1824) is not known in units above the Rushmere Member. The co-occurrence of *C. septenarius*, *C.* sp. aff. *jeffersonius*, *C. madisonius*, and an early form of *C. madisonius* that has fewer ribs than typical suggests that the Raysor is correlative with the Rushmere Member of the Yorktown. In the Moore House Member, *C. septenarius* has not been found. As seen in Table 1, most of the taxa appear first in the Rushmere Member of the Yorktown Formation or its stratigraphic equivalents in North Carolina and South Carolina. The preponderance of molluscan data, then, suggests that the Raysor Formation was deposited during a marine transgression in the late Pliocene. This transgression may have slightly preceded that in the Albemarle (area of the Coastal Plain that includes the northeastern part of North Carolina and the extreme southeastern part of Virginia) and Salisbury Embayments, but for the most part, the transgression coincides with the depositional event associated with the upper

PLATE 3

1. *Marvacrassatella undulata* Say, 1824
   Exterior of a right valve in the Sloan Collection (box 37) at Charleston Museum, Charleston, S.C.; length 106.1 mm, height 71.8 mm.
2. *"Crassatella" gibbesii* Tuomey and Holmes, 1856
   Exterior of a right valve in the Sloan Collection (box 35) at Charleston Museum, Charleston, S.C.; length 30.5 mm, height 22.4 mm.
3. *Astarte floridana* Dall, 1903
   Exterior of a left valve in the Sloan Collection (box 34) at Charleston Museum, Charleston, S.C.; length 26.9 mm, height 22.7 mm.
4. *Astarte concentrica* Conrad, 1834
   Exterior of a right valve (USNM 405355) from USGS collection no. 5295 in the U. S. National Museum, Washington, D.C.; length 18.6 mm, height 16.1 mm.
5. *Astarte* sp.
   Exterior of a left valve (USNM 405356) from USGS collection no. 5295 in the U.S. National Museum, Washington, D.C.; length 17.2 mm, height 10.6 mm.
6. *Lirophora athleta* (Conrad, 1863)
   Exterior of a left valve (USNM 405357) from USGS collection no. 5295 in the U.S. National Museum, Washington, D.C.; length 18.2 mm, height 14.0 mm.
7. *Glossus fraterna* (Say, 1824)
   Exterior of a left valve (USNM 405358) from USGS collection no. 3991 in the U.S. National Museum, Washington, D.C.; length 81.0 mm, height 71.9 mm.
8. *Cyclocardia granulata* (Say, 1824)
   Exterior of a left valve (USNM 408007) from USGS collection no. 5295 in the U. S. National Museum, Washington, D.C.; length 16.9 mm, height 17.0 mm.

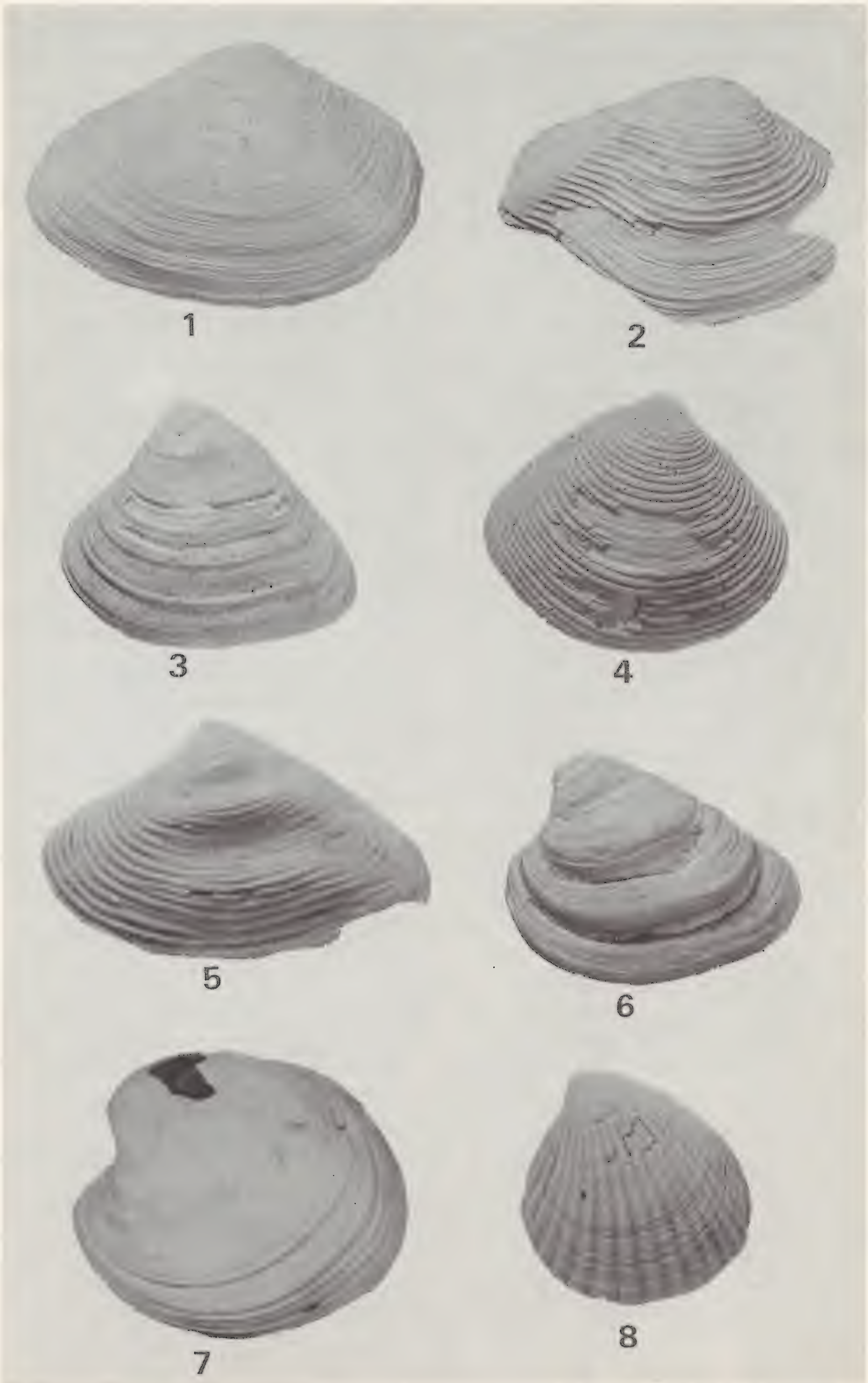


PLATE 3

Yorktown or Rushmere and Morgarts Beach Members of the Yorktown. The Rushmere and Morgarts Beach Members are lithofacies of the same transgressive event. Because of the substrate conditions produced by the coarser basal transgressive shelly sands of the Rushmere, that bed contains a substantially different assemblage than the much more clayey, silty Morgarts Beach Member. In areas in Virginia and North Carolina, where local structural conditions or high areas resulted in similar substrates throughout the sequence, the members are not differentiated, and their assemblages are very similar. In those areas, the Yorktown is referred to as the Rushmere-Morgarts Beach undifferentiated.

The Raysor is probably not correlated with the highest member of the Yorktown, the Moore House Member. The Moore House overlies the Morgarts Beach unconformably and records a separate transgressive event that followed a brief regression. The unit is much less extensive than the Rushmere-Morgarts Beach transgressive event and occupies only about one-fifth of that basin in Virginia. In North Carolina, the Moore House is known only in the subsurface in the area of the Lee Creek Mine, at Aurora, where it is only 10 feet (3 m) thick. Elsewhere in North Carolina, the uppermost Pliocene Chowan River Formation and its equivalent south of the Cape Fear Arch, the Bear Bluff Formation, directly overlie the Rushmere-Morgarts Beach sequence or its undifferentiated equivalents.

VII. FORAMINIFERAL ANALYSIS

The planktic foraminiferal analysis was made on specimens obtained from matrix inside the paired valves of some of the Raysor Formation mollusks. Diverse assemblages were obtained from the matrix associated with *Marvacrassatella undulata* and *Ostrea raveneliana* in Boxes 28 and 38 from the Sloan collection at the Charleston Museum. In addition, a sample from Blackwelder and Ward's (1979) neostratotype for the Raysor was examined for planktic foraminifers. The following taxa were found in the three samples:

Sloan locality 366 - Box 28, in Charleston Museum; matrix from *Marvacrassatella undulata*.

Neogloboquadrina acostaensis (Blow, 1959)
Neogloboquadrina humerosa (Takayangi and Saito, 1962)
Globigerinoides obliquus Bolli, 1957
Globigerinoides ruber (d'Orbigny, 1839)
Globigerinoides quadrilobatus (d'Orbigny, 1846)
Globigerinoides saculifer (Brady, 1877)
Globigerinoides altispira (Cushman and Jarvis, 1936)
Sphaeroidinellopsis seminulina (Schwager, 1866)
Globigerina apertura Cushman, 1918
Globigerina sp.
Orbulina universa d'Orbigny, 1839

Sloan locality 366 - Box 38, in Charleston Museum; matrix from *Ostrea raveneliana*.

Neogloboquadrina acostaensis (Blow, 1959)
Neogloboquadrina humerosa (Takayangi and Saito, 1962)
Globigerinoides obliquus Bolli, 1957
Globigerinoides ruber (d'Orbigny, 1839)
Globigerinoides quadrilobatus (d'Orbigny, 1846)
Globigerinoides saculifer (Brady, 1877)
Globoquadrina altispira (Cushman and Jarvis, 1936)
Sphaeroidinellopsis seminulina (Schwager, 1866)
Globigerina apertura Cushman, 1918
Globigerina sp.
Orbulina universa d'Orbigny, 1839
Globorotalia menardii (d'Orbigny, 1826) right-coiled.
Globorotalia crassula Cushman and Stewart, 1930
Globorotalia punctulata (d'Orbigny, 1826)

Neostratotype of the Raysor Formation of Blackwelder and Ward (1979).

Neogloboquadrina acostaensis (Blow, 1959)
Neogloboquadrina humerosa (Takayangi and Saito, 1962)
Globigerinoides obliquus Bolli, 1957
Globigerinoides ruber (d'Orbigny, 1839)
Globigerinoides quadrilobatus (d'Orbigny, 1846)
Globigerinoides saculifer (Brady, 1877)
Sphaeroidinellopsis seminulina (Schwager, 1866)
Orbulina universa d'Orbigny, 1839
Globorotalia menardii (d'Orbigny, 1826) right-coiled.

In spite of the small volume of the samples, an abundant foraminiferal fauna is present, which includes a relatively large and well-preserved planktic assemblage. Analysis of the planktic assemblage suggests that the Raysor is not lower Pliocene but is upper Pliocene. It is the equivalent of zone N20 Blow (1969) and PL 3 of Berggren *et al.* (1983). The composition of the assemblage also suggests subtropical, open marine, shallow shelf conditions.

VIII. SUMMARY

An analysis of molluscan and planktic foraminiferal assemblages from the Raysor Formation in South Carolina indicates that this unit is of late Pliocene age and is stratigraphically equivalent to the Rushmere and Morgarts Beach Members of the Yorktown Formation in Virginia and northeastern North Carolina and the Yorktown Formation (undifferentiated) of southeastern North Carolina and South Carolina. The unit is also correlative with the Jackson Bluff Formation in western Florida. Planktic foraminifers suggest correlation with Blow's (1969) Zone N20 and Berggren's (1983) Zone PL3. This assignment places the Raysor Formation in the lower part of the upper Pliocene. The formation represents a shallow, open shelf, subtropical to tropical environment where calcarenitic sediments were deposited. The Raysor is a facies equivalent of the shelly, quartzose sands of the Yorktown Formation in northeastern South Carolina and southeastern North Carolina. In those areas, the Yorktown cannot be differentiated into the Rushmere and Morgarts Beach Members as it can in northeast North Carolina and Virginia.

IX. ACKNOWLEDGMENTS

The authors wish to thank Albert E. Sanders of the Charleston Museum, Charleston, S.C., for making available Sloan's extensive mollusk collection from the Raysors Bridge locality. The authors also thank Thomas R. Waller and Warren Blow of the National Museum of Natural History for making the Sloan Raysor Museum collections available to us. We express our appreciation to L. D. Campbell (University of South Carolina, Spartenburg, South Carolina), T. R. Waller (National Museum of Natural History), R. Z. Poore and R. E. Weems (both of the U. S. Geological Survey, Reston, Virginia) for offering suggestions on the manuscript.

X. REFERENCES CITED

BERGGREN, W. A., M. P. AUBRY, N. HAMILTON, 1983, Neogene magnetobiostratigraphy of DSDP Site 516 (Rio Grande Rise, South Atlantic), *in* P. BARKER, D. JOHNSON, *et al.* (eds.): Initial reports of the Deep Sea Drilling Project, v. 72, p. 675-706.

BLACKWELDER, B. W., 1967, Invertebrate fossil collections at the Charleston Museum: South Carolina State Development Board, Division of Geology, Geologic Notes, v. 11, no. 1, p. 5-19.

BLACKWELDER, B. W., and L. W. WARD, 1979, Stratigraphic revision of the Pliocene deposits of North and South Carolina: South Carolina State Development Board, Division of Geology, Geologic Notes, v. 23, no. 1, p. 33-49.

BLOW, W. H., 1969, Late middle Eocene to Recent planktonic foraminiferal biostratigraphy, *in* R. BRONNIMANN and H. H. RENZ (eds.): Proceedings of the First International Conference on Planktonic Microfossils, Geneva, 1967, Volume I. Leiden, E. J. Brill, p. 199-421.

CAMPBELL, L., S. CAMPBELL, D. CALQUHOUN, and J. ERNISSE, 1975, Plio-Pleistocene faunas of the Central Carolina Coastal Plain: South Carolina State Development Board, Division of Geology, Geologic Notes, v. 19, no. 3, p. 49-124. [Published in March, 1976]

COOKE, C. W., 1936, Geology of the Coastal Plain of South Carolina: U. S. Geol. Survey, Bull. 867, p. 1-196.

CRONIN, T. M., 1981, Rates and possible causes of neotectonic vertical crustal movements of the emerged southeastern United States Atlantic Coastal Plain: Geol. Soc. Amer., Bull., Pt. 1, v. 92, p. 812-833.

CRONIN, T. M., L. M. BYBELL, R. Z. POORE, B. W. BLACKWELDER, J. C. LIDDICOAT, and J. E. HAZEL, 1984, Age and correlation of emerged Pliocene and Pleistocene deposits, U. S. Atlantic Coastal Plain: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 47, p. 21-51.

GARDNER, J. A., and T. H. ALDRICH, 1919, Mollusca from the upper Miocene of South Carolina with descriptions of new species: Proc. Acad. Nat. Sci. Philadelphia, 1919, p. 17-53.

HAZEL, J. E., 1971, Ostracode biostratigraphy of the Yorktown Formation (upper Miocene

and lower Pliocene) of Virginia and North Carolina: U. S. Geol. Survey, Prof. Paper 704, p. 1-13.

HAZEL, J. E., 1977, Distribution of some biostratigraphically diagnostic ostracodes in the Pliocene and lower Pleistocene of Virginia and northern North Carolina: U. S. Geol. Survey, Jour. Research, v. 5, no. 3, p. 373-388.

HAZEL, J. E, 1983, Age and correlation of the Yorktown (Pliocene) and Croatan (Pliocene and Pleistocene) Formations at the Lee Creek Mine: Smithsonian Cont. Paleobiology, no. 53, p. 81-199, pls. 1-38.

MANSFIELD, W. C., 1928, New fossil mollusks from the Miocene of Virginia and North Carolina, with a brief outline of the divisions of the Chesapeake Groups: Proc. U. S. National Museum, v. 74, art. 14, p. 1-11. [issued Jan. 14, 1929]

MANSFIELD, W. C., 1935, New Miocene gastropods and scaphopods from Alaqua Creek Valley, Florida: Florida Geological Survey, Bulletin 12, p. 1-64, 5 pls.

MANSFIELD, W. C., 1944, Stratigraphy of the Miocene of Virginia and the Miocene and Pliocene of North Carolina, *in* J. A. GARDNER, 1944, Mollusca from the Miocene and lower Pliocene of Virginia and North Carolina: U. S. Geol. Survey, Prof. Paper 199-A, p. 1-18.

SLOAN, EARLE, 1908, Catalogue of the mineral localities of South Carolina: South Carolina Geological Survey, ser. IV, Bulletin no. 2, p. 1-505.

TUOMEY, M., and F. S. HOLMES, 1855, Fossils of South Carolina, no. 1. John Russell, Charleston, S.C., p. 1-8.

WARD, L. W., and B. W. BLACKWELDER, 1980, Stratigraphic revision of upper Miocene and lower Pliocene beds of the Chesapeake Group, Middle Atlantic Coastal Plain: U. S. Geol. Survey, Bull. 1482-D, p. 1-61, pl. 1-5.

XI. APPENDIX

Localty 5295. Raysors Bridge, Edisto River, Colleton County, South Carolina, Earle Sloan collector, 1909. Collection in the National Museum of Natural History.

Epitonium sp. 1 specimen
Petaloconchus sculpturata H. C. Lea 1 specimen
Kuphus fistula (H. C. Lea) 1 specimen
Turritella sp. 7 specimens
Diodora redimicula (Say) 1 specimen
Dentalium attenuatum Say 6 specimens
Cadulus thallus (Conrad) 3 specimens
Nucula taphria Dall 1 specimen
Yoldia sp. 2 specimens
Nuculana sp. new? 3 specimens
Anadara lienosa (Say) 1 specimen (pl. 1, fig. 5)
Glycymeris subovata tuomeyi Dall 1 specimen (pl. 1, fig. 4) Hazel's (1983, p. 95) ostracode sample came from this specimen
Ostrea raveneliana Tuomey and Holmes 1 specimen (pl. 1, fig. 7)
Ostrea locklini Gardner 6 specimens (pl. 1, fig. 6)
Plicatula marginata Say 1 specimen (pl. 2, fig. 8)
"*Leptopecten*" *irremotis* Olsson and Harbison 1 specimen
Amusium mortoni (Ravenel) 1 fragment
Pteria sp. 1 fragment
Pandora arenosa Conrad 2 specimens
Lucinoma contracta (Say) 1 fragment
Carditamera arata (Conrad) 1 fragment
Cyclocardia granulata (Say) 2 specimens (pl. 3, fig. 8)
Pseudochama corticosa (Conrad) 2 specimens
Echinochama arcinella (Linné) 1 fragment
Lucinisca cribrarius (Say) 53 specimens
Parvilucina multilineata (Tuomey and Holmes) 9 specimens
Callucina keenae Chavan 2 specimens
Dosinia acetabulum? (Conrad) 1 fragment - poor condition
Diplodonta sp. 1 specimen
Diplodonta yorkensis Dall 2 specimens
Aligena aequata (Conrad) 1 specimen
"*Cardium*" sp. prob. "*C.*" *acutilaqueatum* (Conrad) 1 fragment
Glossus fraterna (Say) 2 specimens
Astarte sp. 2 specimens (pl. 3, fig. 5)
Astarte floridana Dall 2 specimens
Astarte concentrica Conrad 1 specimen (pl. 3, fig. 4)
Pitar sayana (Conrad) 1 specimen
Marvacrassatella undulata (Say) 2 specimens
Lirophora sp. prob. *L. athleta* (Conrad) 3 specimens (pl. 3, fig. 6)
Tellina aequistriata (Say) 1 specimen
Tellina declivis Conrad 2 specimens
Semele subovata (Say) 2 specimens
Semele sp.? 1 specimen
Corbula sp.? 1 specimen
Varicorbula sp.? 1 specimen
Corbula inaequalis Say 11 specimens
Hiatella arctica (Linné) 1 specimen
Divaricella quadrisulcata (d'Orbigny) 3 fragments
"*Crassatella*" *gibbesii* (Tuomey and Holmes) 2 young, fragments

Locality 3991. Raysors Bridge, Edisto River, Colleton County, S.C., Sloan and Burns collectors, 1904. Collection in the National Museum of Natural History.

Turritella sp. 6 incomplete specimens (pl.

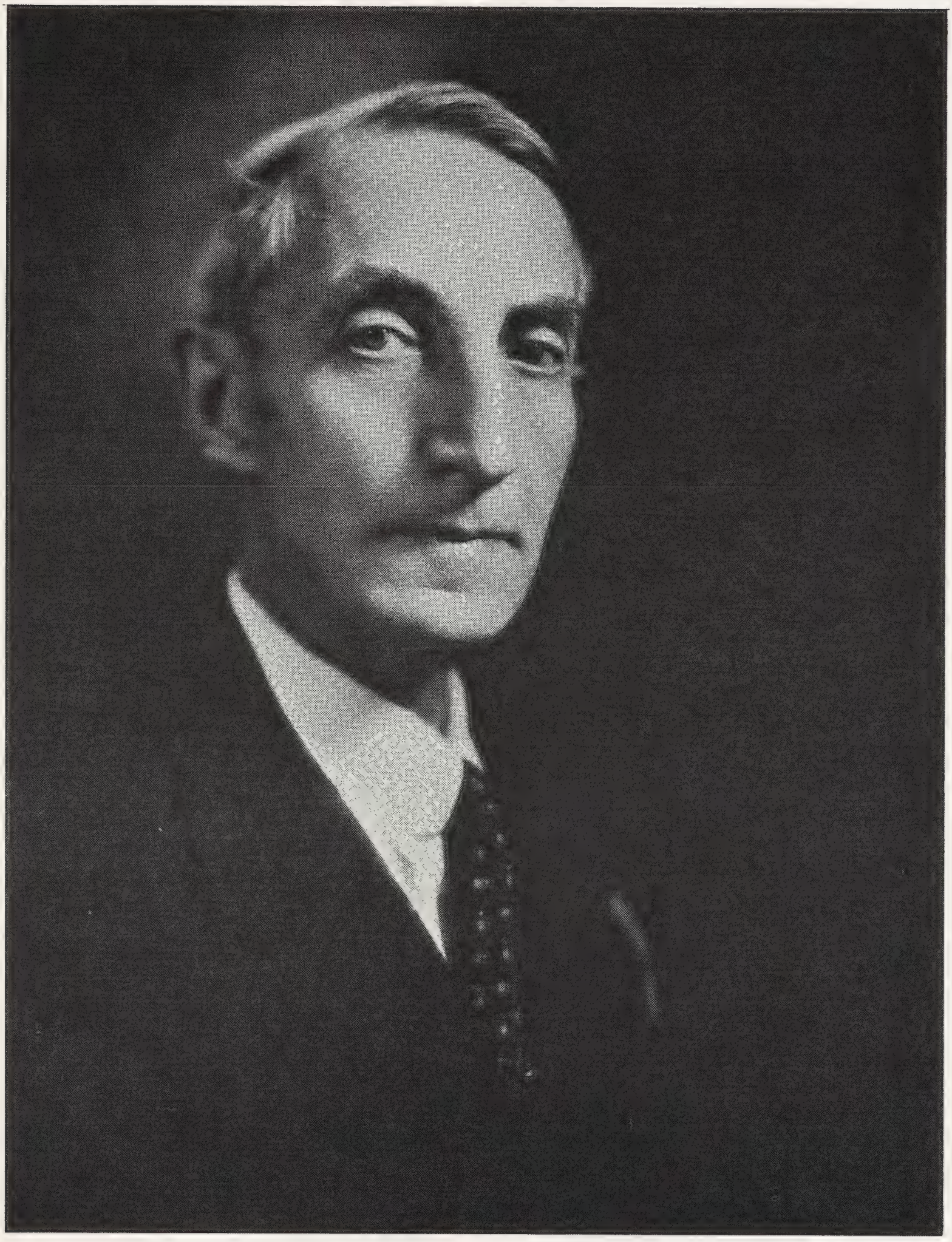
1, figs. 2, 3)
Dentalium attenuatum Say 1 specimen
Ostrea raveneliana Tuomey and Holmes 8 specimens
Anadara lienosa (Say) 1 internal mold
Marvacrassatella undulata (Say) 3 specimens
Glossus fraterna (Say) 7 specimens (pl. 3, fig. 7)
Astarte floridana Dall 1 specimen
Lirophora sp. prob. *L. athleta* (Conrad) 1 specimen
Panopea goldfussii Wagner 1 specimen

Locality 3989. Mouth of Four Hole Swamp, Edisto River, Dorchester County S.C., Burns collector, 1904. Collection in the National Museum of Natural History.

Ostrea locklini Gardner 2 specimens

Locality 366. Raysors Bridge, Edisto River, Colleton County, S.C., Earle Sloan collector, 1909. Collection in the Charleston Museum.

Diodora redimicula (Say) 1 specimen
Turritella sp. 18 specimens; similar to sp. in Rushmere Member
Petaloconchus sp. 1 incomplete specimen
Polinices duplicatus (Say) 1 specimen
Dentalium attenuatum Say 8 entire specimens, 25 fragments
Cadulus thallus (Conrad) 3 entire specimens, 6 fragments
Nucula proxima Say 2 specimens
Nuculana sp. near *N. concentrica* (Say) 15 specimens
Nuculana sp. 4 specimens
Yoldia laevis Say 5 specimens
Anadara sp. 1 specimen filled with matrix not like other specimens, probably not from Raysors Bridge, no Sloan label
Carolinapecten eboreus Conrad 1 specimen, fewer and stronger ribs than typical
Chesapecten sp., very close to *C. jeffersonius* (Say) 2 specimens (pl. 2, fig. 2)
Chesapecten septenarius (Say) 9 specimens (pl. 2, figs. 1, 3, 4)
Chesapecten madisonius (Say) 1 specimen (pl. 2, fig. 5)
Chesapecten sp. 1 specimen, immature
Amusium mortoni (Ravenel) 1 fragment
Ostrea raveneliana Tuomey and Holmes 15 specimens including adults and juveniles; matrix removed from one double-valve for foraminifers.
Ostrea locklini Gardner 1 specimen
Astarte concentrica Conrad 1 specimen
Astarte floridana Dall 2 specimens (pl. 3, fig. 3)
"*Crassatella*" *gibbesii* (Tuomey and Holmes) 2 immature specimens (pl. 3, fig. 2)
Marvacrassatella undulatus (Say) 9 specimens including adults and immature
Cyclocardia granulata (Say) 3 specimens
Pseudochama corticosa (Conrad) 3 specimens (pl. 1, figs. 8, 9)
Chama sp. 2 very young, worn
Lucinisca cribrarius (Say) 112 specimens
Parvilucina multilineatus (Tuomey and Holmes) 35 specimens
Callucina keenae Chavan 2 specimens
Phacoides sp. 2 immature specimens
Divaricella quadrisulcata (d'Orbigny) 2 specimens, 1 fragment
Glossus fraterna (Say) 3 specimens
Dosinia acetabulum? (Conrad) 1 broken, worn specimen
Pitar sayana (Conrad) 3 immature specimens
Lirophora sp. prob. *L. athleta* (Conrad) 7 specimens
Tellina declivis Conrad 2 specimens
Semele subovata (Say) 2 specimens
Semele sp. prob. *S. subovata* (Say) 2 worn specimens
Caryocorbula inaequalis (Say) 13 specimens
Kuphus fistula (H. C. Lea) 3 specimens
Pandora arenosa Conrad 1 specimen
Balanus sp. 4 fragments



VIGNETTES OF COASTAL PLAIN GEOLOGY

WENDELL CLAY MANSFIELD
(1874-1939)

In 1910, W. C. Mansfield joined the staff of the U. S. National Museum, as a preparator for Dr. W. H. Dall. In time he completed a Doctor of Philosophy degree at George Washington University and rose through the ranks of the Geological Survey, ultimately attaining the grade of Geologist. Mansfield's interests extended the entire length of the Gulf and Atlantic Coastal Plain and resulted in almost 40 works on the faunas and stratigraphy of the area. He is best remembered for his several papers on the Choctawhatchee Group of Florida. (*From* J. B. Reeside, Jr., 1940, Geological Society of America, Proceedings)

OLIGOHALINE FOSSILS FROM THE PLEISTOCENE FLANNER BEACH FORMATION, NORTH CAROLINA

WILLIAM MILLER, III

DEPARTMENT OF GEOLOGY
HUMBOLDT STATE UNIVERSITY
ARCATA, CALIFORNIA

ABSTRACT

Oligohaline fossils occur at two localities within the middle Pleistocene Flanner Beach Formation: at the type section on the Neuse River and near Hills Point on the Pamlico River. At the type section, *Rangia cuneata* (Gray) valves form pods and lenses at the base of the formation, show signs of prolonged exposure on the seafloor prior to burial, and are mixed with mesohaline to polyhaline mollusks. At Hills Point a sparse association of *Rangia* and polychaete worm burrows occurs in a thick mud bed also located at the base of the Flanner Beach. Analysis of the first locality indicates conditions of winnowing or sediment starvation and mixing of shells from several original benthic communities during initial stages of inundation of the Flanner Beach estuarine basin. In contrast, the second locality contains an essentially undisturbed oligohaline fossil association derived from a single original community that inhabited the margin of this basin.

The Flanner Beach Formation in eastern North Carolina is notable for its richly fossiliferous estuarine deposits. At two locations within the formation (Figure 1) the lowest stratigraphic levels contain an oligohaline fauna consisting largely of the mactrid bivalve *Rangia cuneata* (Gray), which commonly occurs today in the upper parts of estuaries from northern Chesapeake Bay to Veracruz, Mexico (Abbott, 1974; Andrews, 1977). The purpose of this paper is to describe the fossils from these two interesting localities and comment on their significance in the interpretation of Flanner Beach paleoenvironments. Lithostratigraphy of both exposures has been described in detail by Miller (1985, Figs. 6, 7, p. 119-121).

Locality 1. Type Locality of Flanner Beach Formation. – DuBar and Solliday (1963) established the type section of the Flanner Beach Formation at Flanner Beach Recreation Area, south shore of Neuse River, Craven County (Figure 1). As originally defined, the lowest shelly bed in the formation (Unit 2 at their Station 32; DuBar *et al.*, 1974, p. 121) contains abundant *Rangia* valves. This bed is succeeded by shelly layers containing more diverse associations of mollusks indicative of mesohaline to polyhaline environments. As reinterpreted by Miller (1985), the *Rangia* bed delineates the base of the formation (Figure 2a). The "cypress stump bed" beneath this layer of shells is a separate lithostratigraphic unit (see Mixon and Pilkey, 1976). The type section is now deeply weathered and partially obscured by vegetation, but the *Rangia*-rich interval remains clearly visible.

The *Rangia* bed varies greatly in thickness with irregular upper and lower contacts; it pinches out completely in places. *Rangia* shells are abundant and approximately 5-10% are still articulated. None, however, were seen in living positions

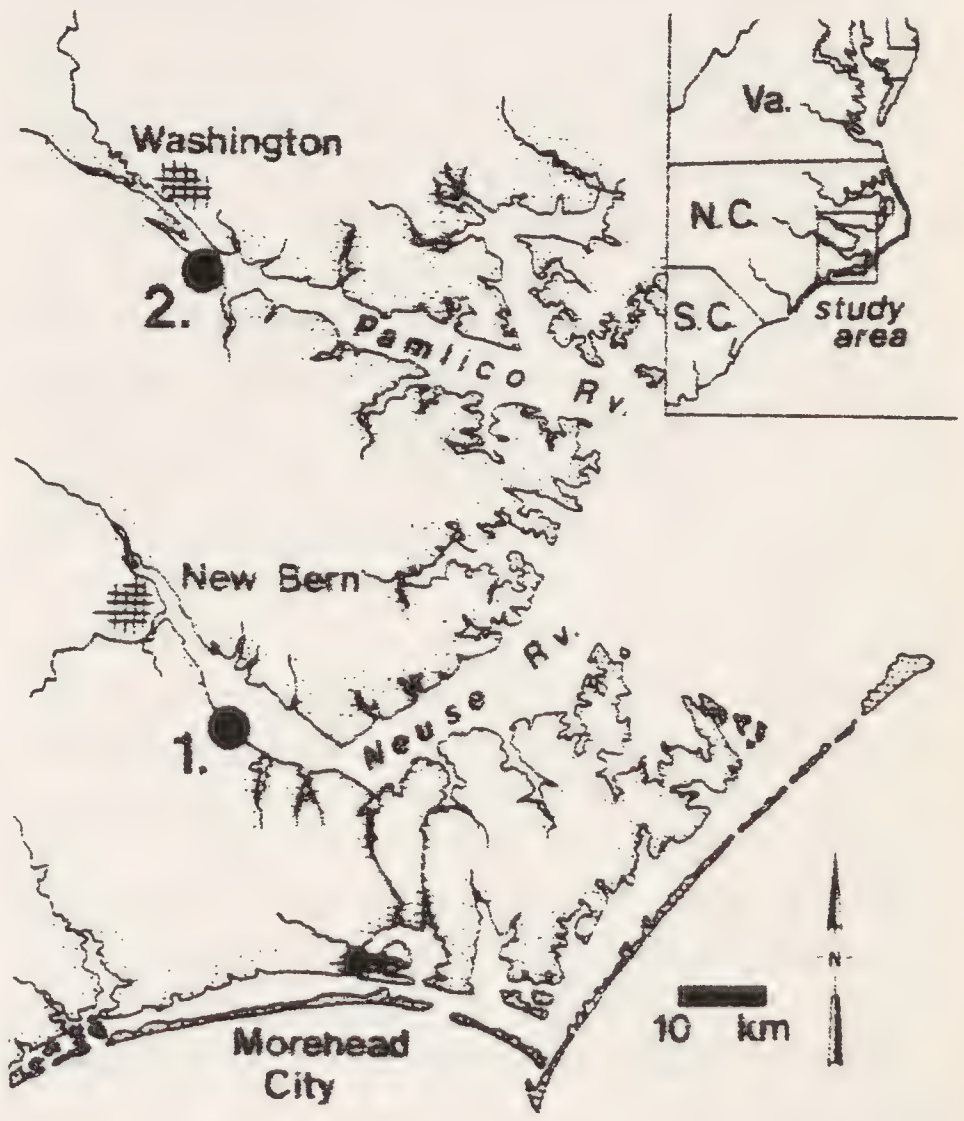


Figure 1. Locality map: *1*, Flanner Beach Recreation Area; *2*, Hills Point on Blounts Bay.

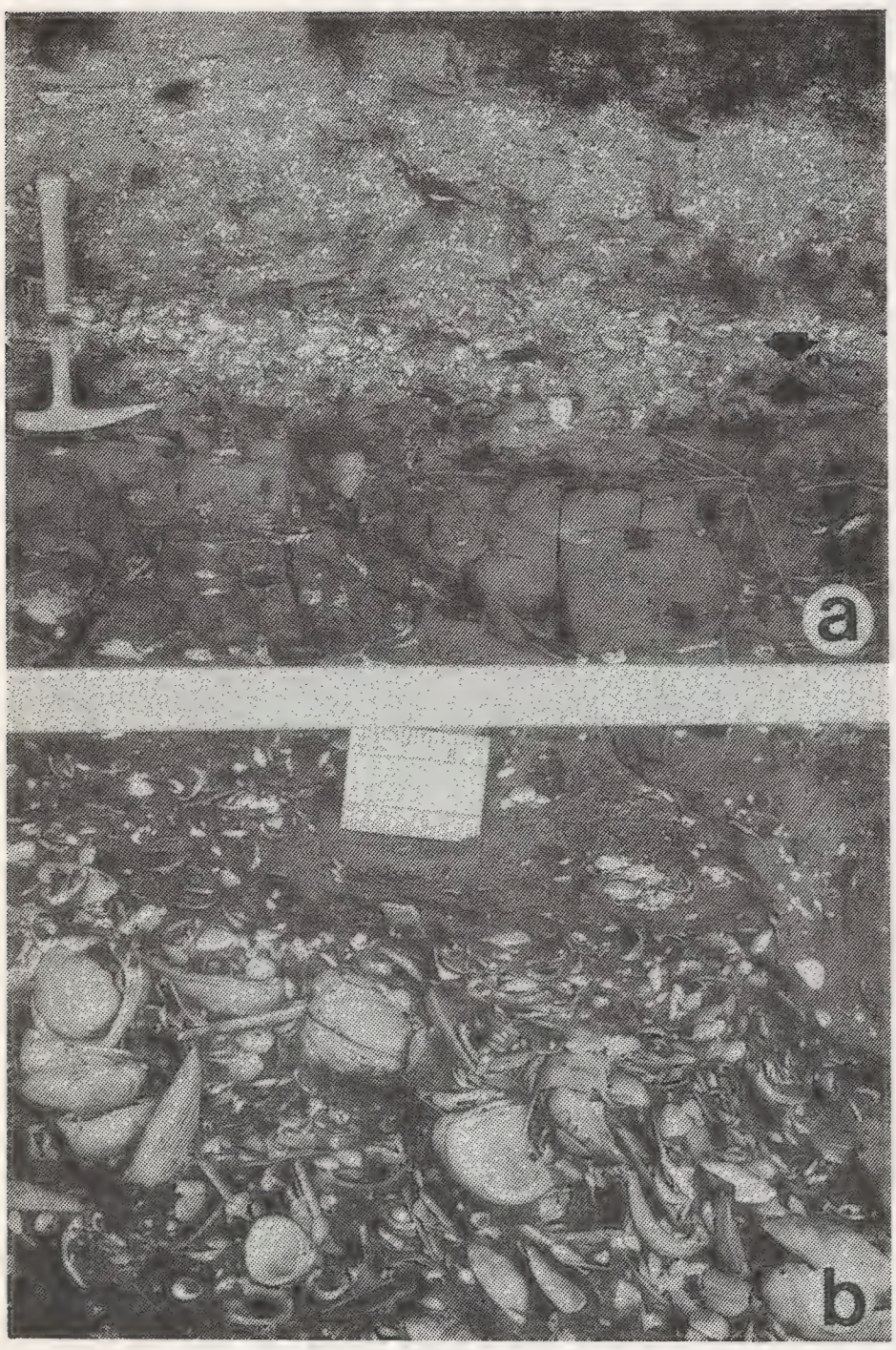


Figure 2. Locality 1 – Flanner Beach study site: *a*, base of Flanner Beach Formation with *Rangia* shell lenses located directly above pre-Flanner Beach fluvial deposits (unconformable contact shown with arrows at right); *b*, close-up view of shell lens showing *Rangia* shells mixed with *Mulinia*, *Ensis*, and other typical Flanner Beach mollusks (note nested and stacked valves in varied orientations).

(Figure 2b). Surrounding sediment is olive gray (5 Y 4/1), shelly medium sand containing sand and mud clasts. Intermixed with *Rangia* are abundant shells of typical Flanner Beach mollusks: *Mulinia lateralis* (Say); *Ensis directus* (Conrad); *Dinocardium robustum* (Lightfoot); *Nuculana acuta* (Conrad); *Nassarius* spp.; *Acteocina canaliculata* (Say); and *Polinices duplicatus* (Say). This mixture of taxa is ecologically incompatible as most of the species prefer higher average salinity than *R. cuneata*. The fossil deposit, then, is a mixed assemblage containing elements from several different benthic communities.

Of the 170 *Rangia* valves collected at random, 95 (55.9%) were encrusted with the cheilostome bryozoan *Electra*, 28 (16.5%) had been bored by the endolithic demosponge *Cliona*, and 48 (28.2%) had conical to curvilinear dissolution pits and trenches that predated final entombment (as shown by epibionts occurring within the pits). A few valves were bored by ctenostome bryozoans and algae. This pattern of shell utilization and damage suggests a long period of exposure on the seafloor or repeated exhumation prior to burial. Ratio of left to right valves in the sample is 91:79, but smallest valves are typically larger than 1 cm in length. Biofabric of shells in the sediment consists of all orientations from concordant with bedding to oblique, with both stacking and nesting of valves in lenticular to pod-shaped accumulations (Figure 2b).

The *Rangia* bed at Locality 1 is either a Type III or IV shell bed in the genetic classification proposed by Kidwell (1986, p. 10), in which a shelly concentration occurs directly above either an omission or erosion surface and grades upward into comparatively less shelly sediments. Such concentrations may result from return of net sediment accumulation to a sediment-starved site (Type III), or from a change from erosional processes to conditions of sediment accumulation (Type IV).

Locality 2. Type Locality of Hills Point Member. – Miller (1985) proposed the name Hills Point Member for the basal mud unit of the Flanner Beach Formation in the Blounts Bay area, Beaufort County. The bottom meter of this member contains a sparse oligohaline fossil deposit consisting of *Rangia cuneata*, small branching burrows, larger unbranched burrows, fossil driftwood, and borings in the wood (Figure 3). Fossils occur in a sticky, medium dark gray (N 4) mud averaging 2.5 m thick. The lowest 2 to 3 cm is cemented by limonite, forming a moderate to light brown (5 YR 3/4-5/6) mudstone ledge (Figure 3a). Most of the fossils are in limonitic mudstone slabs that have weathered out of this layer.

Rangia specimens are found in the slabs as casts and external molds of valves (Figure 3c) and articulated shells (Figure 3d). Based on counts of molds preserved on four large slabs, the average density of clams is 38.5/m^2, with at least 14% being the molds of articulated shells. No unequivocal examples of broken or epibiont-encrusted

valves were observed and some articulated individuals were in living positions (Figure 3d). All specimens are mature individuals larger than 1 cm in length.

Thin sand interlaminations within the mudstone are burrow-mottled and occasionally contain discrete branching, cylindrical burrow systems (Figure 3e) resembling miniature *Thalassinoides* (Häntzschel, 1975, Fig. 70, 2b). These biogenic structures are comparable to the smaller versions of polychaete burrows described from Georgia estuaries by Howard and Frey (1980, Figs. 27, 34). Tenore (1972) has documented the regular co-occurrence of *R. cuneata* with the eurytopic polychaete worm *Nereis succinea* in oligohaline areas of the modern Pamlico River. Thus, these small burrows and burrow-mottled fabrics in the Hills Point Member may have resulted from nereid bioturbation.

In soft mud located above the limonite-cemented base larger, unbranched burrows, approximately 1 cm in average diameter and filled with sand, are rarely found. These structures are referable to the ubiquitous ichnogenus *Planolites* (Häntzschel, 1975, p. W95), and may have been produced by crustaceans or large polychaetes.

Small phytoclasts are fairly common in the Hills Point (Miller, 1985), but wood fragments larger than 5 mm in longest dimension are rare. One large piece of wood, apparently fossil driftwood, contained several rounded, cylindrical borings averaging about 5 mm in diameter and filled with mud matrix (Figure 3b). No woodground organisms were found within the borings. The structures are questionably referred to the ichnogenus *Teredolites* (Bromley *et al.*, 1984). The driftwood probably floated to its entombment site from an area of higher average salinity where wood-boring bivalves, such as the pholadid *Martesia*, were common.

This co-occurrence of *Rangia* with small, branching burrows constitutes an essentially undisturbed oligohaline fossil association. Low density of *Rangia* and fine-grained sediments point to deposition in a deep, quiet-water estuarine environment. By comparison, *Rangia* densities in shallow estuarine margin settings can exceed 200 individuals/m^2 (Tenore, 1972, p. 59). The thin bioturbated sand interlaminations could record storm-related transport of coarser sediments into channel areas from the margins.

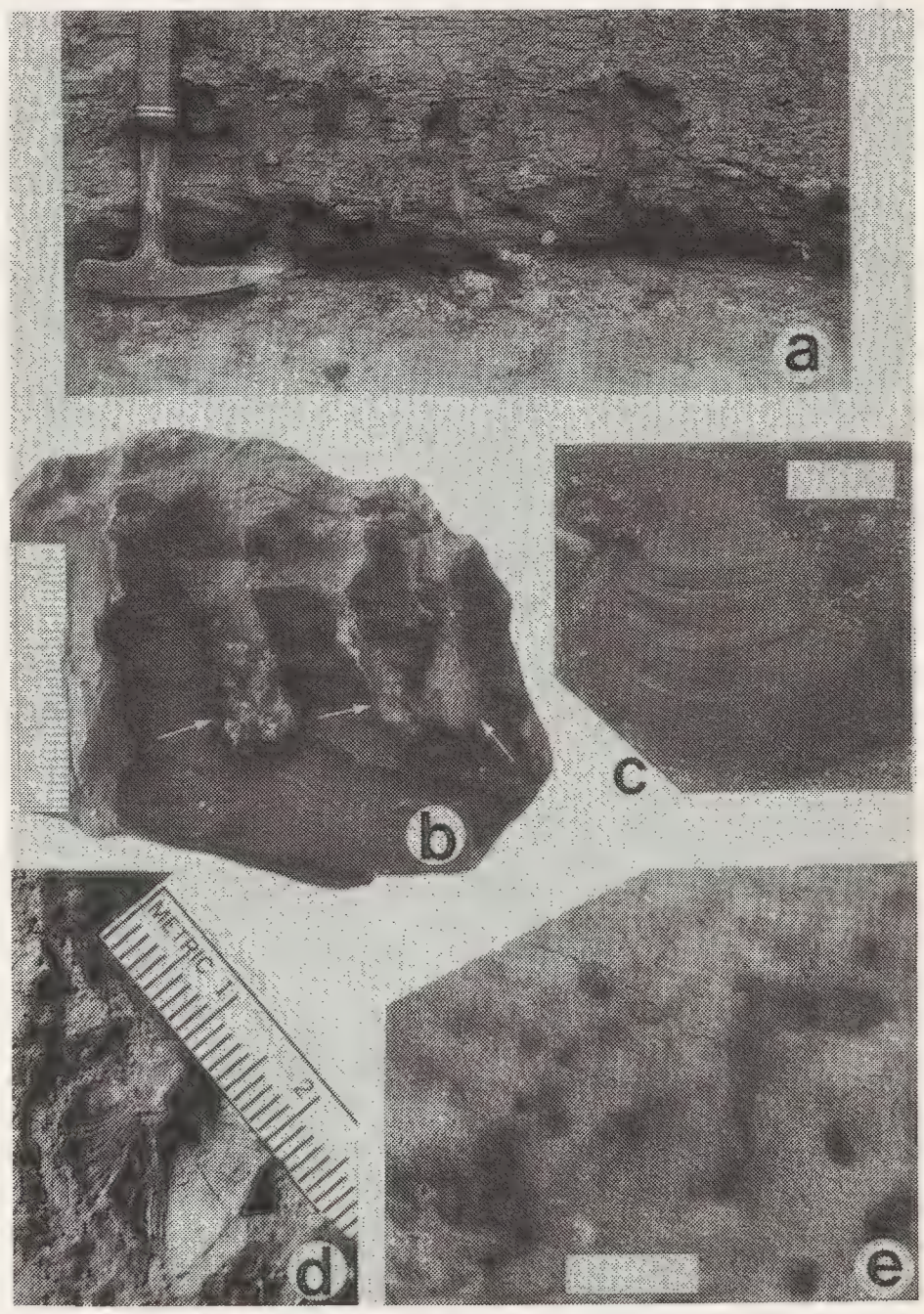


Figure 3. Locality 2 – Hills Point study site: *a*, base of Flanner Beach Formation and Hills Point Member marked by limonitic mudstone (dark band) unconformably above pre-Flanner Beach fluvial deposits; *b*, bored fragment of fossil driftwood (scale in cm's and mm's; arrows point to individual ?*Teredolites* borings); *c*, cast of *Rangia cuneata* left valve (bar represents 1 cm); *d*, external mold of an articulated *R. cuneata* shell (scale as in *b*); *e*, polychaete worm burrows highlighted by limonite in sand interlamination from the basal limonitic mudstone shown in *a* (bar scale represents 1 cm).

Significance. – The two localities reveal that initiation of estuarine conditions at Flanner Beach Recreation Area and Blounts Bay proceeded in sharply different ways. Locality 1 shows signs of shell concentration resulting from winnowing or sediment starvation, with mesohaline and polyhaline fossils mixed with *Rangia* shells

that were exposed on the seafloor for a prolonged interval of time. By comparison, Locality 2 appears to have formed by continuous accumulation of fine-grained sediments and organic remains in the upper portion of an estuary. Higher salinity did not rapidly succeed early oligohaline conditions at this site. Interlayered sand, mud, and burrow-mottled beds of the Mauls Point Member conformably overly the Hills Point Member at Locality 2, and may signal the gradual initiation of a more open lagoonal, higher salinity environment in the Blounts Bay area (Miller, 1985, p.108). Although the Locality 1 area became the center of a large lagoon during the Flanner Beach depositional cycle, Locality 2 seems to have been always on the landward periphery of this extensive estuarine basin.

REFERENCES

ABBOTT, R. T., 1974, American Seashells (2nd Ed.) Van Nostrand Reinhold, New York, 663 p.

ANDREWS, J., 1977, Shells and Shores of Texas. Univ. Texas Press, Austin, 365 p.

BROMLEY, R. G., S. G. PEMBERTON, and R. A. RAHMANI, 1984, A Cretaceous woodground: the *Teredolites* ichnofacies: Jour. Paleont., v. 58, p. 448-498.

DUBAR, J. R., and J. R. SOLLIDAY, 1963, Stratigraphy of the Neogene deposits, lower Neuse Estuary, North Carolina: Southeast. Geol., v. 4, p. 213-233.

DUBAR, J. R., J. R. SOLLIDAY, and J. F. HOWARD, 1974, Stratigraphy and morphology of Neogene deposits, Neuse River estuary, North Carolina, *in* R. Q. OAKS, Jr. and J. R. DUBAR (eds.), Post-Miocene Stratigraphy, Central and Southern Atlantic Coastal Plain. Utah State Univ. Press, Logan, p. 103-122.

HÄNTZSCHEL, W., 1975, Trace Fossils and Problematica (2nd. Ed.), Treatise on Invertebrate Paleontology, Part W. Geol. Soc. Amer. and Univ. Kansas, 269 p.

HOWARD, J. D., and R. W. FREY, 1980, Holocene depositional environments of the Georgia coast and continental shelf, *in* J. D. HOWARD, C. B. DEPRATTER, and R. W. FREY, Excursions in Southeastern Geology, the Archaeology-Geology of the Georgia Coast: Guidebook 20, Geol. Soc. Amer., p. 66-134.

KIDWELL, S. M., 1986, Models for fossil concentrations: paleobiologic implications: Paleobiology, v. 12, p. 6-24.

KIDWELL, S. M., F. T. FÜRSICH, and T. AIGNER, 1986, Conceptual framework for the analysis and classification of fossil concentrations: Palaios, v. 1, p. 228-238.

MILLER, W., III, 1985, The Flanner Beach Formation (middle Pleistocene) in eastern North Carolina: Tulane Stud. Geol. Paleont., v. 18, p. 93-122.

MIXON, R. B., and O. H. PILKEY, 1976, Reconnaissance geology of the submerged and emerged Coastal Plain Province, Cape Lookout area, North Carolina: U. S. Geol. Survey, Prof. Pap. 859, 45 p.

TENORE, K. R., 1972, Macrobenthos of the Pamlico River estuary: North Carolina: Ecol. Monogr., v. 42, p. 51-69.

APPENDIX

Locality Register

Locality 1. Shell pods and lenses 1.4 to 1.7 m above beach level in bluffs at Flanner Beach Recreation Area, Croatan National Forest, south shore of Neuse River, Craven County, North Carolina; Havelock 7.5' quadrangle.

Locality 2. Basal 1 m of mud bed located 1.7 to 4.2 m above beach level in bluffs 0.2 km upstream from Camp Hardee and 1.2 km west of Hills Point, south shore of Pamlico River, Beaufort County, North Carolina; Blounts Bay 7.5' quadrangle.

July 20, 1988

GIANT AGGLUTINATED FORAMINIFERIDS FROM FRANCISCAN TURBIDITES AT REDWOOD CREEK, NORTHWESTERN CALIFORNIA, WITH THE DESCRIPTION OF A NEW SPECIES OF *BATHYSIPHON*

WILLIAM MILLER, III
DEPARTMENT OF GEOLOGY
HUMBOLDT STATE UNIVERSITY
ARCATA, CALIFORNIA

The Franciscan Central Belt is a Late Mesozoic terrane composed of dislocated submarine fan deposits, splinters of oceanic crust and blocks of "exotic" lithologies (*e.g.* glaucophane schist) of uncertain origin, which are all tectonically mixed in a muddy melange matrix. The belt includes the bedrock units exposed in seacliffs and river valleys in northern coastal California (Aalto, 1976, 1982). Megascopic fossil remains in the flysch blocks are rare (Bailey *et al.*, 1964; Blake and Jones, 1974), with most of the reported occurrences of bivalves and ammonoids probably representing allochthonous faunal elements. As a result of a concentrated effort to find organic remains, Franciscan submarine fan deposits are now yielding a unique indigenous biota of locally diverse trace fossils associated with hollow, siliceous tubes (Miller, 1986a, b). The tubular fossils are best assigned to the foraminiferid genus *Bathysiphon*, considering their skeletal structure and overall morphology (a study of biologic affinities and paleoecology is in progress; Miller, in prep). The purpose of this report is to document the second occurrence of these unusual tubes in Central Belt turbidites, which includes a new species. Type material has been deposited in the U.S. National Museum of Natural History (USNM), Washington, D.C.

The fossils described and illustrated herein were collected in 1976 by a field party mapping the northeastern side of Redwood Creek valley (Fig. 1). All specimens came from dark gray argillite with interbedded sandstone within the "Incoherent Unit of Coyote Creek," a division of the Franciscan Complex shown on the geologic map the field group eventually produced (Harden *et al.*, 1982). This unit is Cenomanian in age, as indicated by the occurrence of the ammonoids *Desmoceras (Pseudouhligella) japonicum* and *Calycoceras* sp. The ammonoid finds excited local interest owing to the biostratigraphic potential, but the siliceous tubes were never studied. The specimens described here were stored in the paleontologic collections of Humboldt State University until Mr. Samuel Morrison, a member of the original mapping party, recently brought them to my attention. This is an important rediscovery not only because good chronostratigraphic control is available for the source rocks, but also because it supplements the existing information on abyssobenthic organisms that inhabited fine-grained ("distal") submarine fan substrata of the Franciscan Complex.

Order FORAMINIFERIDA Eichwald, 1830
Suborder TEXTULARIINA Delage and Hérouard, 1896
Superfamily AMMODISCACEA Reuss, 1862

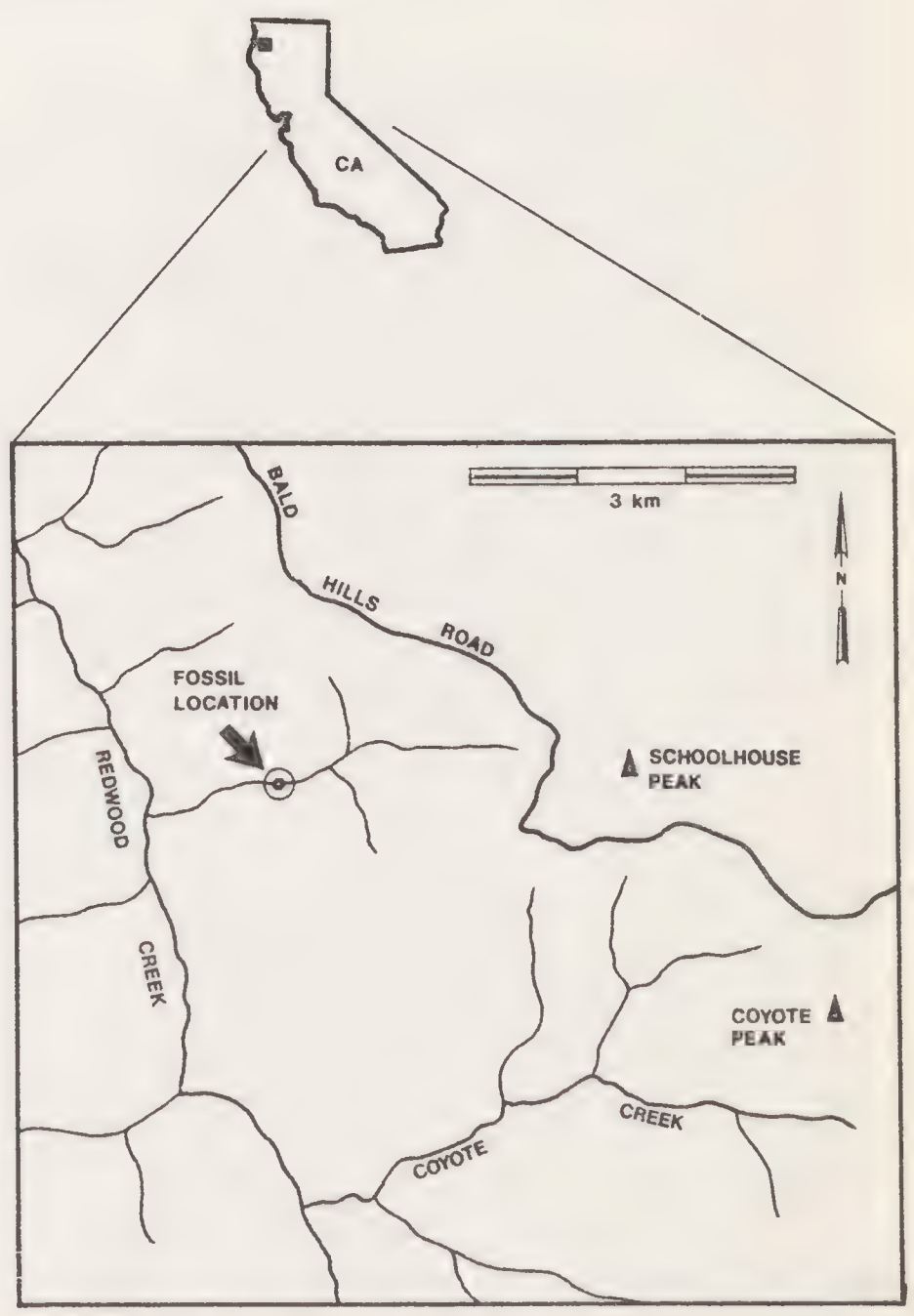


Figure 1. Locality map showing northeastern side of Redwood Creek valley and collecting site of *Bathysiphon cashmanae*.

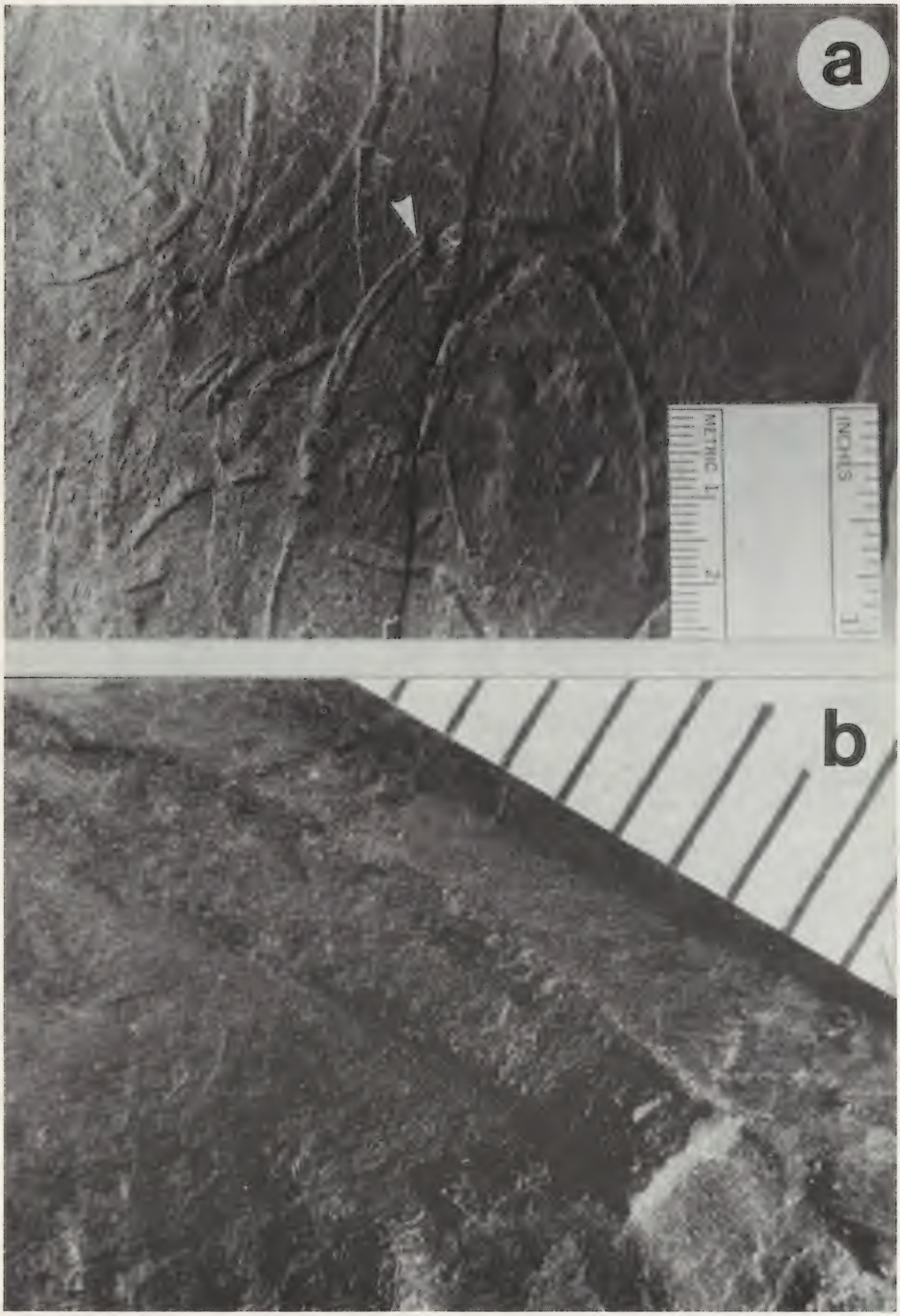


Figure 2. *a*, Argillite slab with 24 specimens of *Bathysiphon cashmanae* (syntypes: USNM 418012 through 418036); *b*, Close view of broken portion of large specimen indicated by arrow in *a* (scale in mm's).

Family ASTRORHIZIDAE Brady, 1881
Subfamily RHIZAMMININAE Rhumbler, 1895
Genus BATHYSIPHON M. Sars
in G. O. Sars, 1872

BATHYSIPHON CASHMANAE
W. Miller, III, n. sp.
Figs. 2a, b; 3

Description: Test free, large, elongate, longitudinally tapered and slightly curved (in silhouette like the scaphopod *Dentalium*); cross-sections of adoral (mature) regions elliptical, but more circular in narrower adapical (immature) regions; wall is generally thicker than the width of the hollow internal cavity, with weakly developed surface striations that are discontinuous and oriented subparallel to long axis of the test; wall composed of apparently structureless, light gray, translucent, microcrystalline silica; test traversed by weak annular constrictions at irregular intervals and creased longitudinally by a furrow that is strongest in adoral regions of flattened specimens; both ends of test open.

Dimensions: Longest test (broken), 45 mm; maximum outer diameter observed, 2 mm; narrowest section through a tapered adapical region, 0.8 mm; arc (depth of bow of test, from inside of curved test to straight line connecting the ends, Fig. 3) of longest specimen, 7 mm.

Syntypes: Slab with about 24 broken tests and segments on one surface, USNM 418012 through 418036, inclusive.

Discussion: Specimens of *B. cashmanae* are similar to curved, tubular fossils that have been regarded by other workers as worm tubes (*i.e.*, *Terebellina* Ulrich, 1910; *Yokoia* Hatai and Noda, 1975). The biologic affinity of these tubes is in doubt, as are some assignments of tubular fossils to *Bathysiphon* in the absence of soft-parts (J. H. Lipps, *in litt.*, 1987). Certain features of the tests of *B. cashmanae* look worm-like, such as the curved, tapering shape, transverse constrictions, and the longitudinal furrow. Several other characteristics compare favorably with descriptions of modern *Bathysiphon* tests (see Cushman, 1910, p. 30-33; Loeblich and Tappan, 1964, p. C186; Gooday, 1983), including: 1) structural simplicity of the siliceous skeleton; 2) absence of a regular, well-developed surface ornamentation; 3) unbranched test open at both ends and lacking chambers; and 4) original flexibility of the test wall, suggested by the variable degree of development of the axial crease. Development (or accentuation) of transverse constrictions, longitudinal furrow, and to some degree the overall curvature of the test are probably partially dependent upon post-entombment deformation of an originally flexible skeleton (see Malecki, 1973). The large size (greater than 40 mm in length) of *B. cashmanae* is not incompatible with the size ranges of certain living species of *Bathysiphon* (*cf.*, Hatai and Saito, 1962); *B. filiformis* M. Sars, 1872, from the North Pacific Ocean, may attain a length of over 50 mm. Another Pacific species, *B. rufum* de Folin, 1886, may be conspicuously marked by transverse constrictions of the test and is slightly curved (Cushman, 1910). Based upon the characters of the test alone, *B. cashmanae* is most likely a giant agglutinated foraminiferid that inhabited the outer regions of a deep-sea fan.

The new species resembles the previously described Central Belt tube fossil, *B. aaltoi* Miller, 1986, in its large size and weak longitudinal striations on exterior surfaces of the best preserved tests. Both have thick walls composed of translucent, microcrystalline silica. *Bathysiphon cashmanae* differs in being sabre-shaped and smaller (recently discovered specimens of *B. aaltoi* from Point Saint George, Del Norte County, exceed 80 mm in length; Miller, in prep.).

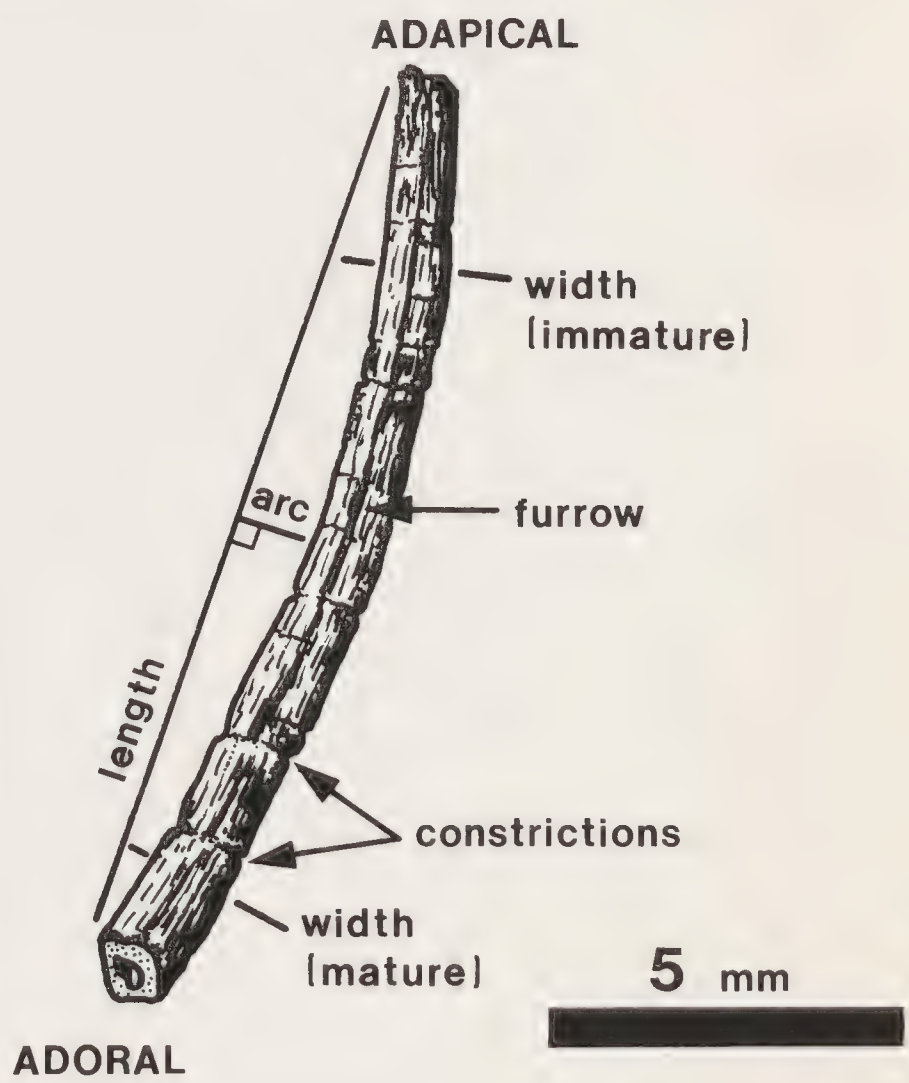


Figure 3. Reconstruction of *Bathysiphon cashmanae* showing terminology used in text to describe test morphology.

Etymology: This new foraminiferid is named in honor of Dr. Susan M. Cashman, Associate Professor of Geology at Humboldt State University and authority on the structural evolution of the Coast Ranges of northern California.

BATHYSIPHON AALTOI
W. Miller, III, 1986

Discussion: A few specimens of *B. aaltoi*, which was first recognized in Facies D turbidites at Point Saint George, Del Norte County, co-occur with *B. cashmanae* at Redwood Creek. However, the new species has not been found at Point Saint George. Largest segment observed was 22 mm in length and 2 mm in width.

I would like especially to thank Mr. Samuel Morrison for presenting the specimens. Ms. Corrine Sinnott drafted the locality map and Dr. Emily Vokes provided editorial corrections. I also thank Dr. Kenneth Aalto for numerous useful discussions on Franciscan geology, and Dr. Jere Lipps for advice as to how to approach the study of fossil representatives of *Bathysiphon*. Acknowledgment is made to the Donors of the Petroleum Research Fund, administered by the American Chemical Society, for support of this research.

LITERATURE CITED

AALTO, K. R., 1976, Sedimentology of a melange: Franciscan of Trinidad, California: Jour. Sed. Petrol., v. 46, p. 913-929.

AALTO, K. R., 1982, The Franciscan Complex of northernmost California: sedimentation and tectonics, *in* LEGGETT, J. K. (ed.), Trench Forearc Geology: Geol. Soc. London, Spec. Publ. 10, p. 419-432.

BAILEY, E. H., W. P. IRWIN, and D. L. JONES, 1964, Franciscan and related rocks, and their significance in the geology of western California: Calif. Div. Mines Geol., Bull. 183, 177 p.

BLAKE, M. C., Jr., and D. L. JONES, 1974, Origin of Franciscan melanges in northern California, *in* R. H. DOTT, Jr., and R. H. SHAVER (eds.), Modern and Ancient Geosynclinal Sedimentation: Soc. Econ. Paleont. Mineral., Spec. Publ. 19, p. 345-357.

CUSHMAN, J. A.,1910, A monograph of the Foraminifera of the North Pacific Ocean. Part I. Astrorhizidae and Lituolidae: U.S. Natl. Museum, Bull. 71, 134 p.

GOODAY, A. J., 1983, *Bathysiphon rusticus* de Folin, 1886 and *Bathysiphon folini* n. sp.: two large agglutinated foraminifers abundant in abyssal NE Atlantic epibenthic sledge samples: J. Foram. Research, v. 13, p. 262-276.

HARDEN, D. R., H. M. KELSEY, S. D. MORRISON, and T. A. STEPHENS, 1982, Geologic Map of the Redwood Creek drainage basin, Humboldt County, California: U.S. Geol. Survey, Water-Resources Investigations Open-File Report 81-496, 1 sheet.

HATAI, K., and Y. SAITO, 1962, A problematica from the Miocene Bessho Formation in Hagishima County, Nagano Prefecture, Japan: Japanese Jour. Geol. Geograph., v. 33, p. 243-250.

HATAI, K., and H. NODA, 1975, An armored worm from the Miocene Yoko-o Formation, Nagano Prefecture, Japan: Trans. Proc. Palaeont. Soc. Japan, New Series, no. 100, p. 209-219.

LOEBLICH, A. R., and H. TAPPAN, 1964, Sarcodina, chiefly "Thecamoebians" and Foraminiferida: Treatise on Invertebrate Paleontology, Part C, Protista 2, Vol. 1. Geol. Soc. Amer. and Univ. Kansas Press, 511 p.

MALECKI, J., 1973, Bathysiphons from the Eocene of the Carpathian flysch, Poland: Acta Palaeont. Polon., v. 18, p. 163-172.

MILLER, W., III, 1986a, New species of *Bathysiphon* (Foraminiferida: Textulariina) from Franciscan flysch deposits, northernmost California: Tulane Stud. Geol. Paleont. v. 19, p. 91-94.

MILLER, W., III, 1986b, Discovery of trace fossils in Franciscan turbidites: Geology, v. 14, p. 343-345.

MILLER, W., III, *in prep.*, Giant *Bathysiphon* (Foraminiferida) from Cretaceous turbidites, northern California.

ULRICH, E. O., 1910, Fossils and age of the Yakutat Formation: description of collections made chiefly near Kodiak, Alaska: Smithson. Inst., Harriman Alaska Ser., v. 4, p. 124-146.

July 20, 1988

TULANE STUDIES IN GEOLOGY

VOLUME 1, Complete with title page and contents $7.00

VOLUME 2, Complete with title page and contents $7.00

VOLUME 3, Complete with title page and contents $10.00

VOLUME 4, Complete with title page and contents $10.00

VOLUME 5, Complete with title page and contents $10.00

VOLUME 6, Complete with title page and contents $10.00

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

VOLUME 7, Complete with title page and contents $12.00

VOLUME 8, Complete with title page and contents $12.00

VOLUME 9, Complete with title page and contents $12.00

VOLUME 10, Complete with title page and contents $15.00

VOLUME 11, Complete with title page and contents $15.00

VOLUME 12, Complete with title page and contents $15.00

VOLUME 13, Complete with title page and contents $15.00

VOLUME 14, Complete with title page and contents $18.00

VOLUME 15, Complete with title page and contents $18.00

VOLUME 16, Complete with title page and contents $18.00

VOLUME 17, Complete with title page and contents $20.00

VOLUME 18, Complete with title page and contents $20.00

(see earlier issues for individual listing)

Vol. 19, Nos. 1, 2. THE CALCAREOUS NANNOPLANKTON OF THE MIDWAY GROUP (PALEOCENE) OF ALABAMA, by David Reimers; TAPHONOMIC CHARACTERISTICS OF OFFSHORE MOLLUSK SHELLS, SAPELO ISLAND, GEORGIA, by Robert W. Frey and James D. Howard; AN EVALUATION OF THE TAXA *MURICOPSIS* AND *RISOMUREX* (GASTROPODA:MURICIDAE), WITH ONE NEW SPECIES OF *RISOMUREX* and A NEW SPECIES OF *MURICOPSIS (RISOMUREX)* FROM WEST AFRICA, by Emily H. Vokes and Roland Houart; NEW SPECIES OF *BATHYSIPHON* (FORAMINIFERIDA:TEXTULARIINA) FROM FRANCISCAN FLYSCH DEPOSITS, NORTHERNMOST CALIFORNIA, by William Miller, III; PUBLICATION DATES OF HEILPRIN'S EXPLORATIONS ON THE WEST COAST OF FLORIDA, by Richard E. Petit and Druid Wilson, pp. 1-96 (July 31, 1986)– BOUND TOGETHER. $12.00

Vol. 19, Nos. 3, 4. COMMUNITY REPLACEMENT IN ESTUARINE PLEISTOCENE DEPOSITS OF EASTERN NORTH CAROLINA, by William Miller, III; OSTRACODE BIOSTRATIGRAPHY AND PALEOECOLOGY OF THE PLIOCENE OF THE ISTHMIAN SALT BASIN, VERACRUZ, MEXICO, by Maria L. Machain-Castillo; FRESH AND BRACKISH WATER OSTRACODA FROM THE NEOGENE OF NORTHERN VENEZUELA, by W. A. van den Bold; MYTILIDAE (MOLLUSCA:BIVALVIA) FROM THE CHIPOLA FORMATION, LOWER MIOCENE, FLORIDA and AN UNUSUAL DISTORTED *SPONDYLUS* FROM THE MOIN FORMATION (PLEISTOCENE), COSTA RICA, by Harold E. Vokes; NOTES ON THE FAUNA OF THE CHIPOLA FORMATION-XXX: ON THE PRESENCE OF *EUDOLIUM (GALEODOLIUM) SUBFASCIATUM* SACCO (GASTROPODA:TONNIDAE), by Emily H. Vokes; EARLY PLIOCENE *MONTFORTELLA* (FORAMINIFERIDA) FROM ECUADOR, by Drew Haman and Barry Kohl; *KARRERIELLA OBTURACULOIDES*, A NEW AGGLUTINATED BENTHIC FORAMINIFERAL SPECIES and *AMPLECTODUCTINA*, A NEW FORAMINIFERAL GENUS, IN THE SIPHOGENERINODIDAE, by R. Timothy Patterson; pp. 97-191 (December 15, 1986) – BOUND TOGETHER $12.00

VOLUME 19, Complete with title page and contents $20.00

Vol. 20, Nos. 1-3. LATE MIOCENE AND EARLY PLIOCENE SILICEOUS MICROFOSSILS FROM THE UPPER MONTEREY AND LOWER SISQUOC FORMATIONS, SWEENY ROAD, SANTA BARBARA COUNTY, CALIFORNIA, by W. H. Akers, R. E. Marolt, and R. J. Navarette; pp. 1-112 (September 16, 1987) – BOUND TOGETHER. $15.00

Vol. 20, 4. TAXONOMIC INDEX TO VOLUMES 11 THROUGH 20, by Emily H. Vokes; pp. 113-200 (December 31, 1987). $5.00

VOLUME 20, complete with title page and contents $20.00

VOLUME 21, Subscription $20.00

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 21, Numbers 3, 4 October 12, 1988

Number 3

GEOLOGY AND VERTEBRATE PALEONTOLOGY OF A LOWER PERMIAN DEPOSIT ON THE BRAZOS RIVER, BAYLOR COUNTY, TEXAS, WITH THE DESCRIPTION OF A NEW GENUS AND SPECIES OF ACANTHODIAN FISH
WALTER W. DALQUEST, M. JOHN KOCURKO AND JOHN A. GRIMES p. 85

NOTES ON FOSSIL OCTOCORALS AND COMPARISONS OF SOME MODERN AND ANCIENT OCTOCORAL REMAINS
M. JOHN KOCURKO p. 105

SOME MARINE PELECYPOD FAMILIES AND GENERA THAT ARE RELICTS OR LIVING FOSSILS
DAVID NICOL p. 117

FURTHER NOTES ON *EUDOLIUM (GALEODOLIUM) SUBFASCIATUM*
J. GIBSON-SMITH and W. GIBSON-SMITH p. 119

Number 4

GULF COASTAL PLAIN PITTED MILIOLACEA AND RELATED SPECIES IN GRIGNON AND DAMERY, FRANCE
HAROLD V. ANDERSEN p. 121

OSTRACODA OF ALACRAN REEF, CAMPECHE SHELF, MEXICO
W. A. VAN DEN BOLD p. 143

SMITHSONIAN NOV 0 2 1990 LIBRARIES

TULANE UNIVERSITY OF LOUISIANA
New Orleans

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY is devoted primarily to the geology and paleontology of the coasts and adjacent land areas of the Gulf of Mexico and the Caribbean Sea. Each number contains an individual monographic study, or several minor studies. As volumes are completed, title pages and tables of contents will be distributed to subscribers and institutions exchanging the entire series.

Manuscripts submitted for publication are evaluated by the editors and for longer papers by an editorial committee selected from the field of the author(s). Contributors need not be members of the Tulane University faculty.

Manuscripts should be submitted on good paper, as original typewritten copy, double-spaced and carefully corrected. Two carbon copies in addition to the original will help expedite editing and assure more rapid publication.

The cost of excessive illustrations and tabular matter may be charged to the author, and will be computed on the cost above that of a normal 10-point page of text.

An abstract not exceeding three percent of the length of the original article must accompany each manuscript submitted. This will be transmitted to any abstracting journal specified by the writer.

Separate numbers or volumes may be purchased by individuals. Subscriptions are not accepted from institutions publishing comparable series; exchange agreements are invited. Authors may obtain copies for personal use at cost.

Address all communications concerning manuscripts and editorial matters, subscriptions, and orders for individual numbers to the editor. Address exchange inquiries to the exchange director.

When citing this series, authors are requested to use the following abbreviations: *Tulane Stud. Geol. Paleont.*

Price for this number, $12.00

Hubert C. Skinner, *Editor*
Emily H. Vokes, *Editor*
and *Exchange Director*
Tulane Studies in Geology and Paleontology
Department of Geology
Tulane University
New Orleans, Louisiana 70118
U.S.A.

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 21, Number 3 October 12, 1988

GEOLOGY AND VERTEBRATE PALEONTOLOGY OF A LOWER PERMIAN DEPOSIT ON THE BRAZOS RIVER, BAYLOR COUNTY, TEXAS, WITH THE DESCRIPTION OF A NEW GENUS AND SPECIES OF ACANTHODIAN FISH

WALTER W. DALQUEST, M. JOHN KOCURKO AND JOHN V. GRIMES

MIDWESTERN STATE UNIVERSITY
WICHITA FALLS, TEXAS

CONTENTS

Page
I. ABSTRACT 85
II. INTRODUCTION 85
III. DEPOSITIONAL ENVIRONMENT 88
IV. ACANTHODIAN FISHES 89
V. SIGNIFICANCE OF *RODRIGUEZICHTHYES* 97
VI. ASSOCIATED VERTEBRATES 99
VII. COMMENTS ON THE MILLER'S CREEK LOCAL FAUNA 102
VIII. ACKNOWLEDGMENTS 103
IX. LITERATURE CITED 103

I. ABSTRACT

A high concentration of vertebrate fossils is described from a Lower Permian Lueders Formation deposit. The study area is on the Salt Fork of the Brazos River, near the entrance to Miller's Creek, 22 km south of Seymour, Baylor County, Texas. Remains of an undescribed genus and species of acanthodian fish make up more than 90% of the fossils; sharks, coelacanth and paleoniscoid fishes constitute the remainder, with the exception of a few fragments of amphibians and reptiles. The dolostone matrix containing the fossils was deposited in shallow, near-shore marine water. All of the vertebrates, except tetrapods, are considered to be marine. The acanthodian is typified by large size, fin spines being symmetrical in cross-section and without surface sculpture, and scales consisting of a spongy bone core surrounded by concentric layers of orthodentine except externally, where it is covered with successive layers of an enameloid. Each scale bears an elongated posterior spine. Fauna from near Miller's Creek is less diverse in species content than the marine vertebrate fauna discovered in the Lueders Formation near Lake Kemp Dam, 30 km north-northeast of the Miller's Creek site, though both local faunas are nearly contemporary. At Miller's Creek, acanthodians dominate the fauna; at Lake Kemp Dam paleoniscoids constitute the bulk of the fauna.

II. INTRODUCTION

Lower Permian redbeds of north-central Texas yield remains of reptiles and amphibians that have attracted the attention of paleontologists and the public since their discovery more than a century ago. Basic stratigraphy of the region was established by Cummins (1890, 1891). The Wichita and Clear Fork formations of Cummins have since been elevated to groups and each group subdivided into several formations. The integrity of the formations has largely been preserved but there is controversy about the boundaries of the groups. The

EDITORIAL COMMITTEE FOR THIS PAPER:
DAVID S. BERMAN, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania
NICHOLAS HOTTEN, III, U. S. National Museum, Washington, D. C.
BOBB SHAEFFER, American Museum of Natural History, New York, New York

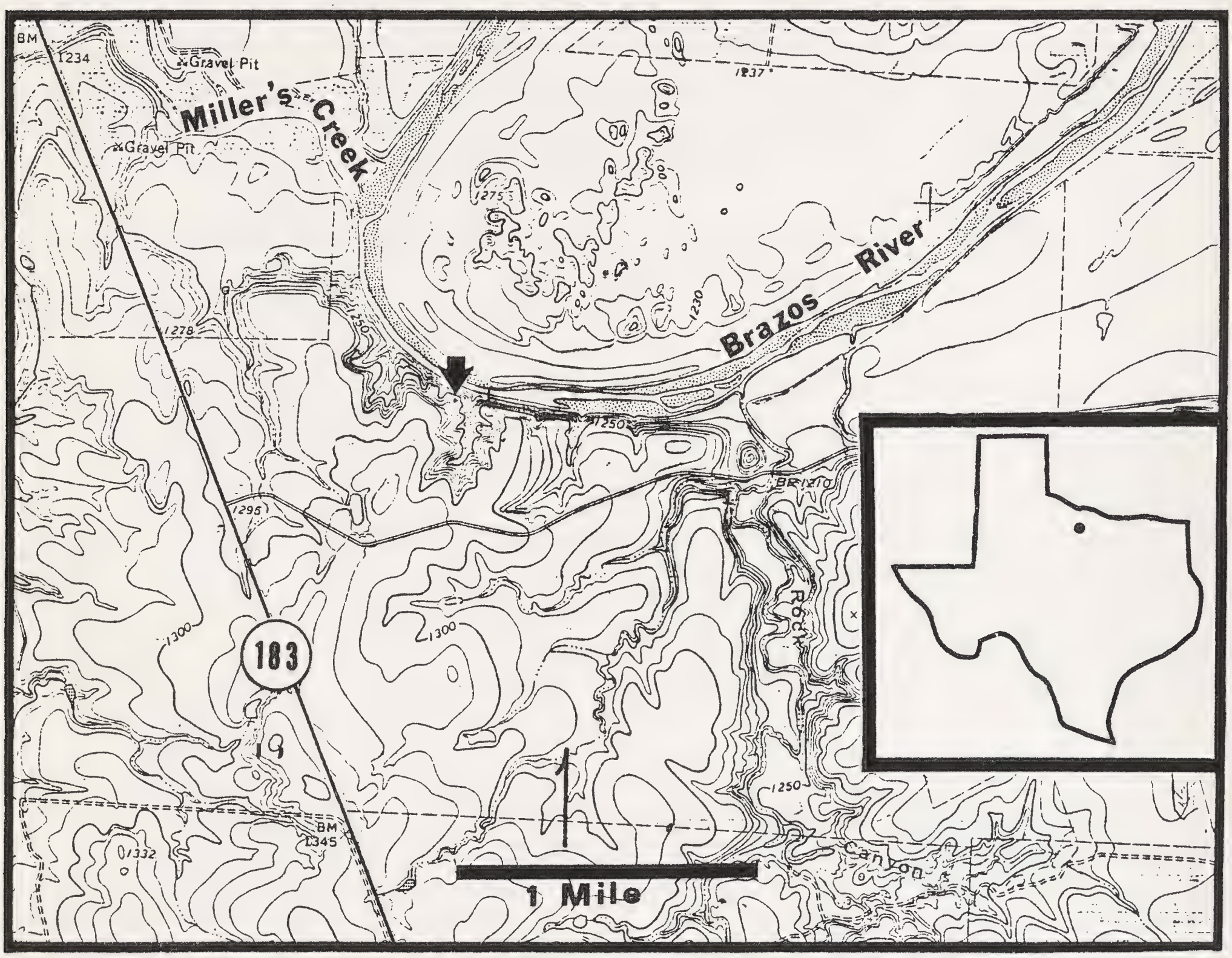


Fig. 1. Map showing the Miller's Creek locality (arrow) approximately 20 km south of Seymour, Texas, along the Salt Fork of the Brazos River. Dot on inset map indicates general location.

position of groups and formations in relation to the Pennsylvanian-Permian boundary is also controversial (Romer, 1935, 1938; Olson, 1958, 1975). We follow Berman (1970) in considering the Wichita-Clear Fork boundary to lie between the Lueders and Arroyo formations.

Regardless of the group boundaries, in north-central Texas the Lueders Formation is distinct. Formations above and beneath the Lueders consist largely of "redbeds," red and vari-colored clays, sandstones and shales of terrestrial or freshwater origin. Limestones or dolostones are few and thin. The Lueders is marked by numerous strata of dolostone and limestone, some of considerable thickness and of marine origin. The Lueders Formation was deposited along the eastern margin of the Early Permian mid-continental seaway and records minor advances and retreats of the sea.

Johnson (1979) thought that Dalquest and Emsoff (1977) erred in placing the Miller's Creek collecting site in the Lueders Formation. He considered it to lie at the boundary of the Bell Plains and Clyde formations and, presuming a 2 degree dip to the northwest, calculated a difference of 85 meters elevation between our study area and the nearest mapped outcrop of the Aa2 "limestone" of the Maybelle Member, upper Lueders Formation. Our calculations dramatically disagree with those of Johnson. The nearest occurrence of the Aa2 "limestone" is beside U.S. Highway 183-283, 5 km north-northwest of our study area. U.S. Geological Survey Topographic Map, Wichita Falls, NI-14-8, shows the 1300 foot contour passing through the Aa2

site. Elevations of other nearby outcrops of the Aa2 "limestone" indicate that there is little or no dip in the immediate area. Garrett *et al.* (1937) show the top of the underlying Clyde Formation to lie 21 meters beneath the Aa2 "limestone." Using U.S.G.S. topographic maps, simple calculations indicate that the Aa2 "limestone" would lie, if present at our collecton site, 1265 feet in elevation. Our collection site is clearly in the lower part of the Lueders Formation.

More important is the limestone at the base of our measured section (Fig. 2). The Lake Kemp limestone marks the top of the Lueders Formation, the Talpa limestone the top of the Clyde Formatin, and the Bead Mt. limestone the top of the Bell Plains Formation. We found no limestones between the Aa2 outcrop of the Maybelle "limestone" beside Highway 183-283 and the limestone at the base of our measured section. We consider this basal limestone to be the Talpa, the top of the Clyde. Our fossil collection site is, therefore, near the bottom of the Lueders Formation.

The vertebrate fossils discovered in the late 1800s and early 1900s came from the strata above and below the Lueders. The Lueders was the orphan formation of early workers. Romer (1938) did not list the Lueders as a productive formation and remarked, "Few vertebrates are to be expected here; a *Trimerorhachis* skull is the only specimen definitely known to the writer to have been derived from this formation." Romer, who studied Texas Permian vertebrates and geology from 1926 until his death in 1973, restricted his investigations to the formations of the Wichita Group and older. The formations of the Clear Fork and younger groups were studied by E. C. Olson, then of the University of Chicago (Berman, 1970). The intermediate Lueders Formation was avoided by both.

Read (1943) first reported a vertebrate fauna, as well as its environmental significance, from the Lueders Formation near Lake Kemp in Baylor County. Other papers concerned with fossils from the Lueders Formation include Dalquest (1963, 1966, 1968), Berman (1968, 1970), Schaeffer and Dalquest (1978), and Dalquest and Kocurko (1986). Fossil plants were described by Mamay (1966). All of the above,

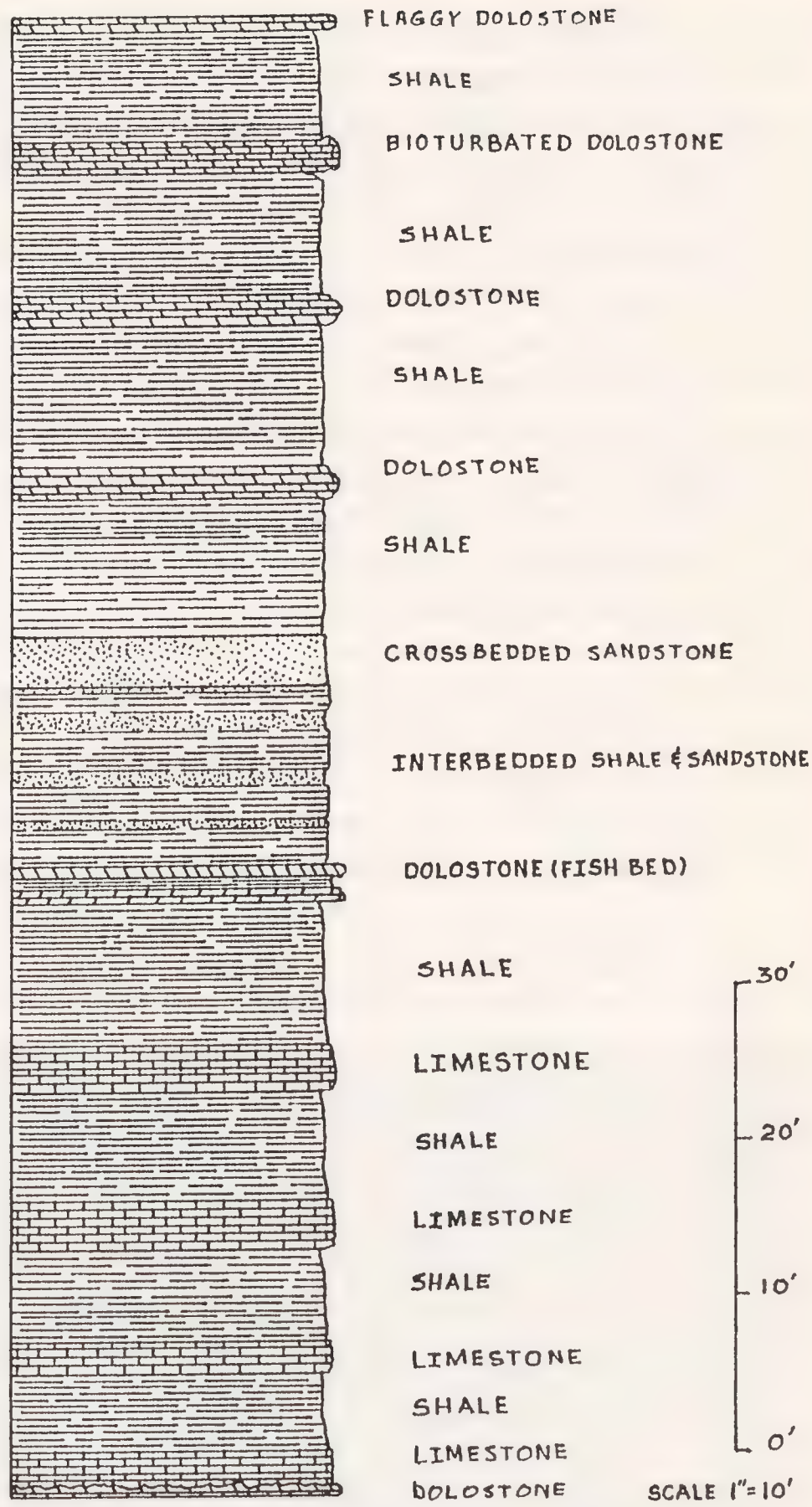


Fig. 2. Measured section at type locality of *Rodriguezichthyes luedersensis*.

and virtually all mention of vertebrate fossils from the Lueders Formation, are based on specimens collected in an area of a few square kilometers near the Lake Kemp Dam in Baylor County.

Dalquest and Emsoff (1977) reported abundant remains of acanthodian fishes, and a few associated vertebrates, from the Lueders Formation on the banks of the Salt Fork of the Brazos River. The location is on the Brazos River near the mouth of Miller's Creek, Baylor County, approximately 30 km SSW of the Lake Kemp Dam. The fauna listed by Dalquest and Emsoff is different from that discovered near Lake Kemp (Dalquest and Kocurko, 1986) and warrants description.

III. DEPOSITIONAL ENVIRONMENT

The Lueders Formation may never produce the quantity and quality of large vertebrates for which the other Lower Permian formations of the region are famous, but is important in other ways. As the boundary between Wichita and Clear Fork groups it is approximately the boundary between the equivalent Wolfcampian and Leonardian groups of marine sedimentary terminology. Climate and terrestial ecological conditions in the region during Wichita time were essentially humid, with little or no relief. Following the deposition of the Lueders Formation, the land was better drained and the climate more arid. In this region the Lueders Formation marks the end of swamp conditions.

The limestone and dolostone layers of the Lueders Formation shield softer sediments from erosion. Consequently, exposures are often steep, permitting study of the vertical extent of outcrops. As one moves laterally along an exposure, strata, especially sandstones, vary in thickness. Each change reflects events of the fluctuating sea margin during Lueders time. The marine strata of the Lueders Formation were probably deposited during a short interval of time.

The Permian-age sediments exposed at the Miller's Creek locality (Fig. 1) total 94 feet in thickness (Fig 2; we use feet rather than meters here, since most geologic sections described from Texas have been so measured). The section, represents a general regression of the Permian sea. The lower half consists of alternating dark shales and fossiliferous limestones. The limestones are rich in invertebrate fossils. Some of the shale layers yield a sparse vertebrate fauna of dermal scales, isolated teeth and other remains of fishes. The limestones of the lower part of the section are generally micritic and contain hematite pseudomorphs after framboidal pyrite.

Fig. 3. Part of a concentration of *Rodriguezichthyes luedersensis* fin spines. Note orientation, indicating gentle water curents or wave action. Scale is in 1 cm units.

Fossil remains consist of gastropods, pelecypods, ostracods, foraminifers and tabulate corals. Terrigenous clasts are occasionally incorporated into the limestone units. The limestone and shale sequence is interpreted to be marine in origin. The sediments probably accumulated in moderately shallow, quiet waters.

With continued regression of the Permian sea, marine sediments were covered by tidal or supratidal deposits. The first of these deposits is an orange dolostone unit, which we term the "fish layer." The unit consists of a sucrosic dolostone with minor internal bedding. The orange color, on freshly exposed surfaces, is probably due to hematitic and limonitic stain, whereas weathered surfaces are gray and similar in appearance to beds above and below. Fossil material in the fish layer consists of disarticulated bones, spines, teeth, scales of fish and rarely isolated bones of tetrapods. Lateral concentrations of these remains give rise to apparent bedding within the unit. Most of the elongate spines are oriented parallel to major bedding planes. Clustering and roughly parallel orientation of spine material (Fig. 3) indicates a possible reworking by marine current during high tides or storm tides. The presence of tetrapods in the unit indicates a nearshore tidal position.

Above the fish layer is an accumulation of pale gray dolostones, vari-colored shales and sandstones. This upper part of the section is interpreted as representing terrestrial conditions. The dolostones are probably tidal to supratidal deposits, whereas the sandstones and shales represent coastal, terrestrial deposits. The dolostones are virtually unfossiliferous other than trace fossils (bioturbation). The sandstones and shales likewise are barren of fossil remains. The terrestrial section terminates in a dense, flaggy dolostone. The only fossils in this unit are colonies of coral, measuring up to 25 by 37 cm in horizontal width and 4 cm thick.

IV. ACANTHODIAN FISHES

Emsoff (1975) discovered the "fish layer" at the top of the low bluff on the west side of the Brazos River. The richest concentration of fossils is approximately one kilometer south of the mouth of Miller's Creek in the orange dolostone matrix. The fossiliferous layer has been traced over several thousand square meters. All of the fossils on which the following accounts are based were obtained at the discovery site, where they are especially abundant. Elsewhere fossils are usually sparse, though some heavy concentrations of acanthodian spines were noted. The dominant and most prominent fossils in the "fish layer" are of acanthodians.

Fig. 4. *Rodriguezichthyes luedersensis* fin spines, sectioned to show cross-sectional shape. Inset: left, shape in upper portion; right, lower portion. Scale is in 1 cm units.

Acanthodians are best known from the Old World but were reported from the eastern United States and Canada almost a century ago (Zidek, 1976). The geological range of the Order Acanthodiformes extends from the Upper Silurian to the Lower Permian. Much of our recent understanding of American acanthodians comes from the studies of Zidek (1973, 1975a, 1975b, 1976, 1977, 1980), and a revision of the order Acanthodii by Denison (1979).

Acanthodians were not reported by early workers in the Texas Permian beds. Skulls and skeletons of amphibians and reptiles were found in unconsolidated Permian sediments and the hard, clay-pebble channel conglomerates that held disarticulated remains of acanthodians, as well as fragments of other vertebrates, were largely ignored. The first acanthodian reported from Texas was an almost complete but tiny, fingerling, individual (Dunkle and Mamay, 1956). This was collected 30 km SSE of Seymour, Baylor County, and only about 30 km from the present study area at Miller's Creek. The specimen is from the Clyde Formation, and stratigraphically lower than the fossils from the Lueders Formation.

By the late 1960s it was common knowledge among students of the Texas Permian that acanthodian remains were present in the channel conglomerates of the Wichita Group (Admiral and Bell Plains formations), but the first published record of such occurrence was by Simpson (1974). The geologically youngest Texas specimens come from the Lueders Formation (Dalquest and Emsoff, 1977). However, Simpson (1973) reported acanthodians from a pond deposit in the lower part of the Hennessey Group near Frederick, Oklahoma. This occurrence is presumably equivalent to the Vale Formation, Clear Fork Group, of Texas. Olson (1958) worked extensively in the pond and channel deposits of the Vale Formation in Texas, and some of his localities (1958 map) are only about 80 km SSW of Simpson's site. Olson reported no acanthodian fossils in his systematic list of Vale fossils.

Fig. 5. Stout, curved spine (partly concealed by larger spine fragment) thought to be pelvic spine of *Rodriguezichthyes luedersensis*. Note scales in matrix.

Perhaps Simpson's site lies lower in the section than he believed.

Simpson's acanthodian fossils from Oklahoma and all Texas Permian occurrences known to us in the Wichita Group are from freshwater pond or channel deposits. The specimens are much smaller than those from the Lueders Formation. The acanthodian remains described here come from a marine dolostone stratum that contains fossil corals. Acanthodians occur throughout the fish layer and the underlying layer of black to gray shaley clay as well, and must have accumulated over a considerable period of time. The fossils can scarcely represent a catastrophic event that swept vast numbers of dead freshwater fishes into the sea. The sediments at the Miller's Creek site indicate shallow marine water, not remote from shore, but also not an estuary where dead freshwater fishes might be transported and accumulate. It is concluded, therefore, that the acanthodian remains at the Miller's Creek locality are of a marine species.

The acanthodians of the fish layer are completely disarticulated. We estimate that well over 30 square meters of fresh dolostone from the fish layer were exposed by splitting slabs, but no articulated bones or scales were discovered. Important generic characters of acanthodians include the positions and relative sizes of the fin spines, but this cannot be determined from the Miller's Creek material. Scales, however, are present in the dolostone by the countless millions, and we have made a detailed study of them. Scales of acanthodians are diagnostic at the generic level (Brotzen, 1934; Denison, 1979). In both morphology and histology the scales from Miller's Creek are unique among described acanthodians. The acanthodian represented by the fossils in the fish layer represents a heretofore unknown genus and species which is described below.

RODRIGUEZICHTHYES new genus

Type species: Rodriguezichthyes luedersensis new species.

Generic Diagnosis. Large, marine acanthodian having large, symmetrical fin spines measuring 100-135 mm in length. Scales unique in bearing an elongated posterior spine and in their construction of a core of spongy bone, base of concentric layers of orthodentine, and a crown of enameloid substance.

Etymology. Named for Dr. Louis J. Rodriguez, President of Midwestern State University, in recognition of his continued support of paleontological research.

RODRIGUEZICHTHYES LUEDERSENSIS new species

Holotype. Nearly complete fin spine (ichthyodorulite) No. 12303, Midwestern State University Collection of Fossil Vertebrates, preserved in dolostone matrix along with numerous isolated scales.

Type Locality. Top of low bluff on the west bank of the Salt Fork of the Brazos River, 22 km SSE Seymour, 1 km S of the mouth of a small tributary, Miller's Creek, Howard Farmer Ranch, Baylor County, Texas.

Horizon. Lueders Formation, top of the Wichita Group, Lower Permian Period.

Etymology. Name is derived from the Lueders Formation.

Diagnosis. Same as for genus.

Description of holotype. The holotype fin spine is nearly complete and partly embedded in orange dolostone that also contains numerous scales of *Rodriguezichthyes luedersensis.* The spine measures: greatest straight-line length, 116 mm; greatest anteroposterior diameter, 7.8

Fig. 6. Scapulacoracoid of *Rodriguezichthyes luedersensis.* Overall length is 22 mm. Bar scale is 10 mm.

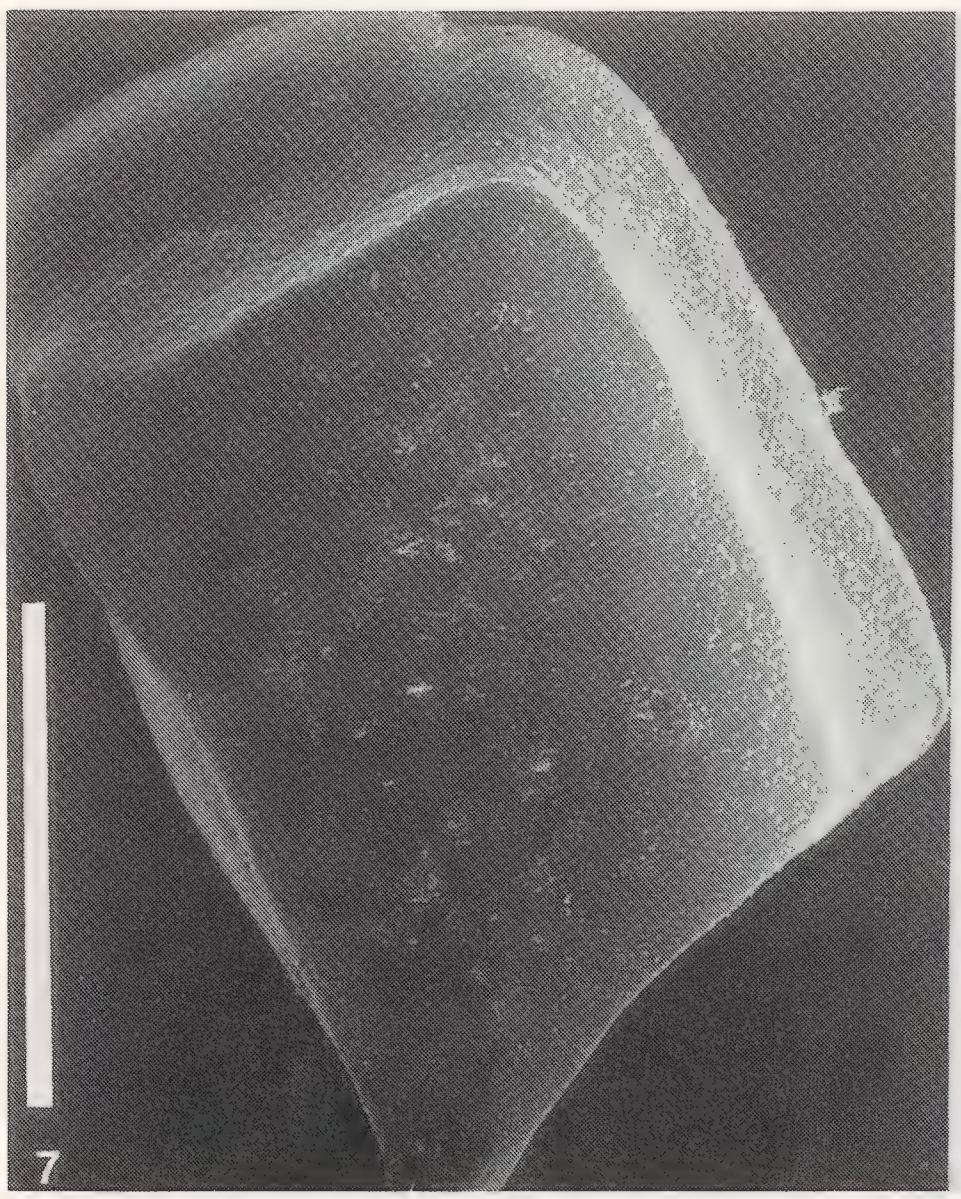
mm. The spine lacks ornamentation other than the longitudinal grooves.

Discussion. A variety of different kinds of acanthodian scales have been described and figured (Brotzen, 1934; Denison, 1979). Most bear strong surface ornamentation; the scales of *Rodriguezichthyes* have smooth surfaces lacking ornamentation. Most described scales lack posterior spines, have short, blunt spines or have multiple spines. None have slender, elongated spines like the spines of *Rodriguezichthyes*. Most are rhomboidal in dorsal aspect, or somewhat triangular and broader than long. The scales of *Rodriguezichthyes* are almost oblong. The combination of elongated, rectangular scales with smooth surfaces and single slender, elongated posterior spines is not duplicated in any acanthodian genus that we have seen figured.

The histology of the scales of *Rodriguezichthyes* appears to be unique in that they have a core of spongy bone (Fig. 11 and 12) surrounded by a base of orthodentine and a crown of an enameloid substance. A bony core seems to be absent in scales of other described acanthodians, and the crown surface is composed of dentine or mesodentine (Denison, 1979). Brotzen (1934) figures Schmeltz [enamel] in the crowns of several genera and families but this is not cited by Denison.

Acanthodian remains make up almost all of the fossils in the fish layer; other fossils are rare. Remains are completely disarticulated. Stouter structures (scales, spines and scapulae) often suffer some minor damage and fracturing but are generally preserved intact. The moderately thick circumorbital plates are usually well-preserved. The thin endochondral bones, such as of the visceral skeleton, often poorly ossified to begin with, are almost all fragmented and shattered. Thin, flat fragments of bone are randomly dispersed through the matrix of the fish layer. What appear to be parts of neural or haemal arches, parts of the branchial skeleton, or cranial ossifications can sometimes be tentatively recognized but not with certainty.

Complicating the problem are the re-



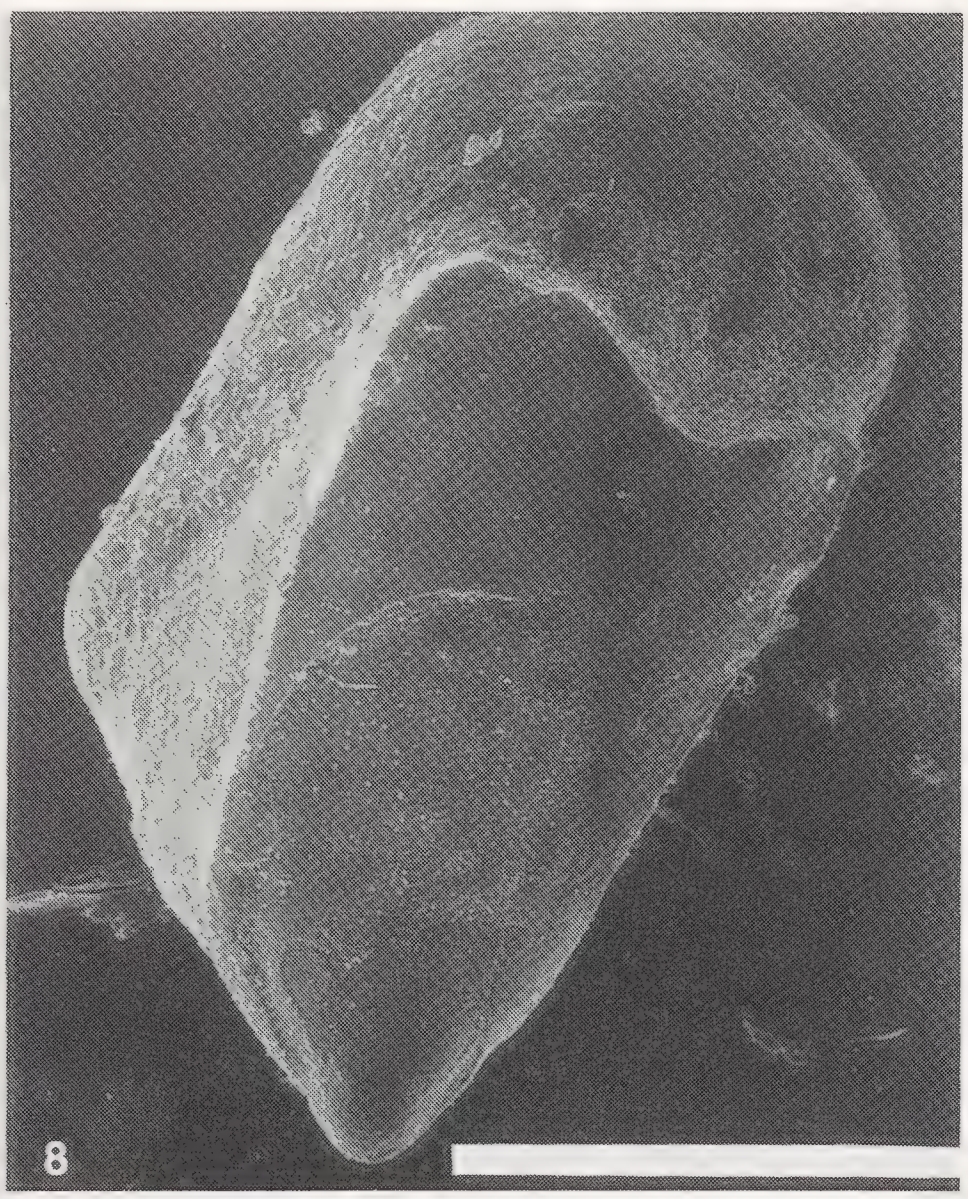


Fig. 7. Crown view of *Rodriguezichthyes luedersensis* scale showing hard, shiny enameloid and anterior expansion of scale base. Bar scale represents 1 mm. Fig. 8. Anteroblique view of another scale showing anterior expansion of base and parts of two outer layers of enameloid chipped away. Bar scale represents 1 mm.

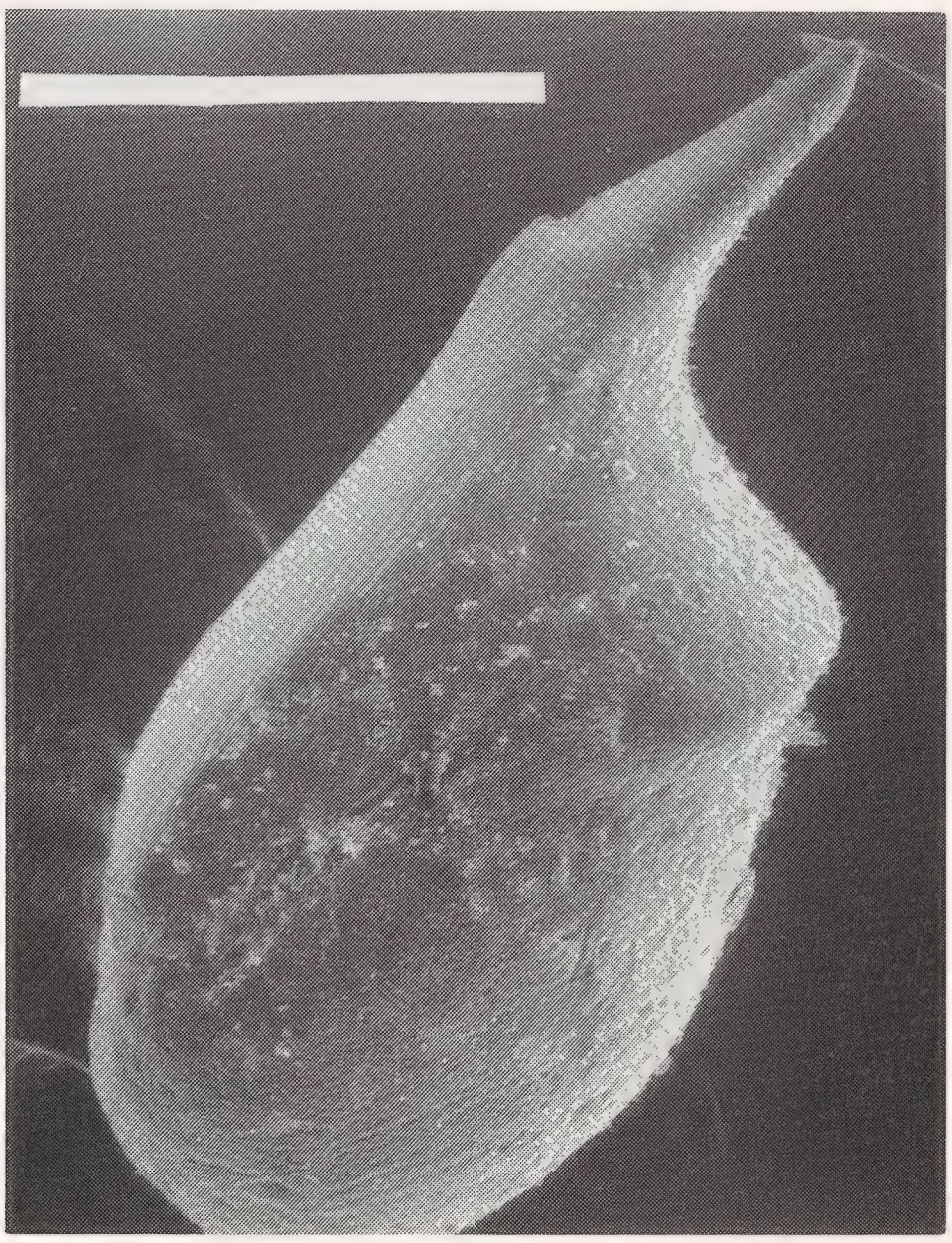


Fig. 9. Side view of typical scale showing posterior spine, posterior excavation for expanded scale base of next posterior scale, and rounded, almost ball-like ventral side of scale base. Bar scale represents 1 mm.

mains of osteicthian fishes. These are uncommon compared with remains of acanthodians but numerous phyllodont tooth plates were recognized. This indicates that other large fishes were present in some numbers, and their bones are mingled through the fish layer. The thin, cycloid scales of coelacanths are not preserved in the fish layer but fragments that might be dermal and endochondral bones of the head, and parts of vertebral arches of coelacanths, are fossilized. As a result, the only elements that we identify with confidence as acanthodian are fin-spines, scales, scapulae, and circumorbital plates.

The fin spines of *Rodriguezichthyes luerdersensis* are the largest reported from North America. Moy-Thomas and Miles (1971) note that most European acanthodians were less than 200 mm in length but Orvig (1967) mentions a fish two meters long. Zidek (1976) states that there is no allometry in the genus *Acanthodes* and implies that this is true of all acanthodians. In *Acanthodes bridgei* Zidek, from the Upper Pennsylvanian of Kansas, Zidek computed the length of the pectoral spines, the longest spine in the body of *Acanthodes*, to be 0.16-0.20 of the total length of a fish. The longest spine measured by Zidek was 76 mm in length and the articulated fish was 410 mm in total length. If this ratio holds true for *Rodriguezichthyes*, where the longer spines commonly measure 100 mm and the maximum observed was 135 mm, then the Miller's Creek acanthodians were 500 to 844 mm in total length.

Zidek (1975a) has recognized two types of freshwater acanthodian spines from Oklahoma: symmetrical in cross-section (dorsal and anal fins); and flattened, asymetrical spines (pectoral and pelvic fins). We have studied hundreds of sections of *Rodriguezichthyes* spines and all resemble the median, symmetrical spines figured by Zidek (Fig. 4). Most of the spines from Miller's Creek are long but stout and gently curved, whereas some are shorter and more curved (Fig. 5). The shorter spines may be pelvics, and the very longest pectorals, but this is not certain. However, we found no flattened, asymmetrical spines like those of the freshwater acanthodians from Texas and Oklahoma.

Isolated circumorbital plates are common and many are intact. Unfortunately, the external surfaces of these dermal bones adhere tightly to the matrix, and invariably, when the dolostone is split the internal surfaces only are exposed. The

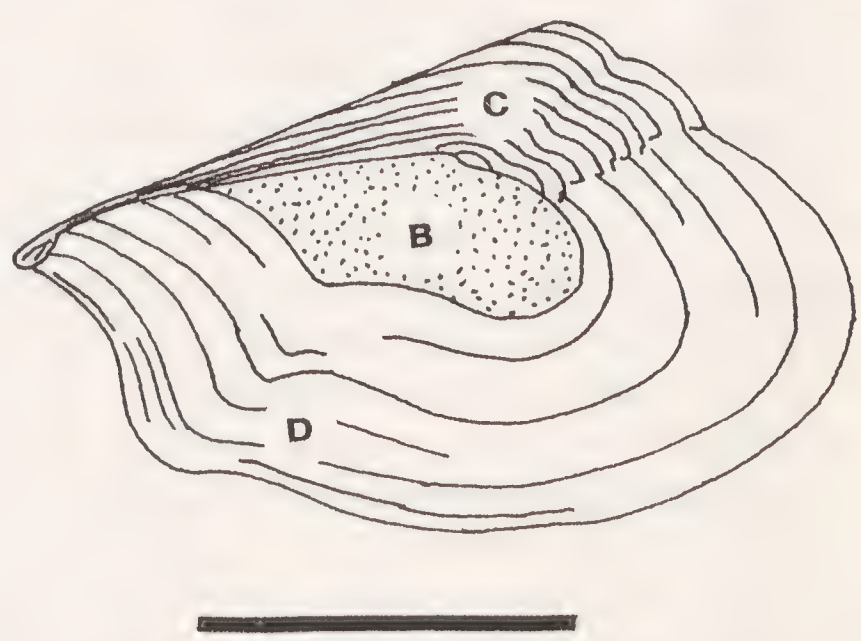
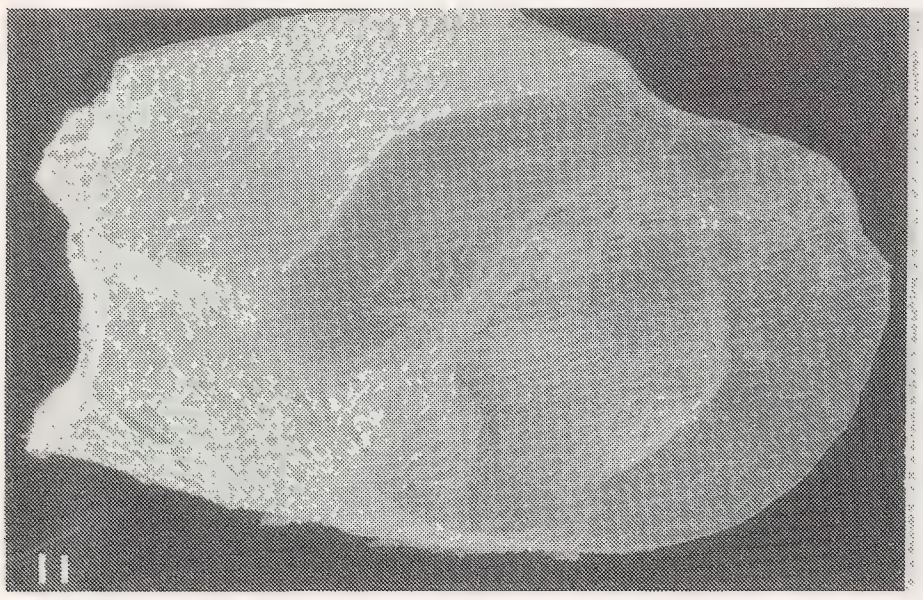


Fig. 10. Vertical section through scale of *Rodriguezichthyes luedersensis* showing enameloid crown (c), spongy bone core (b) and dentine base (d). Same scale shown in figure 20. Bar scale represents 1 mm.



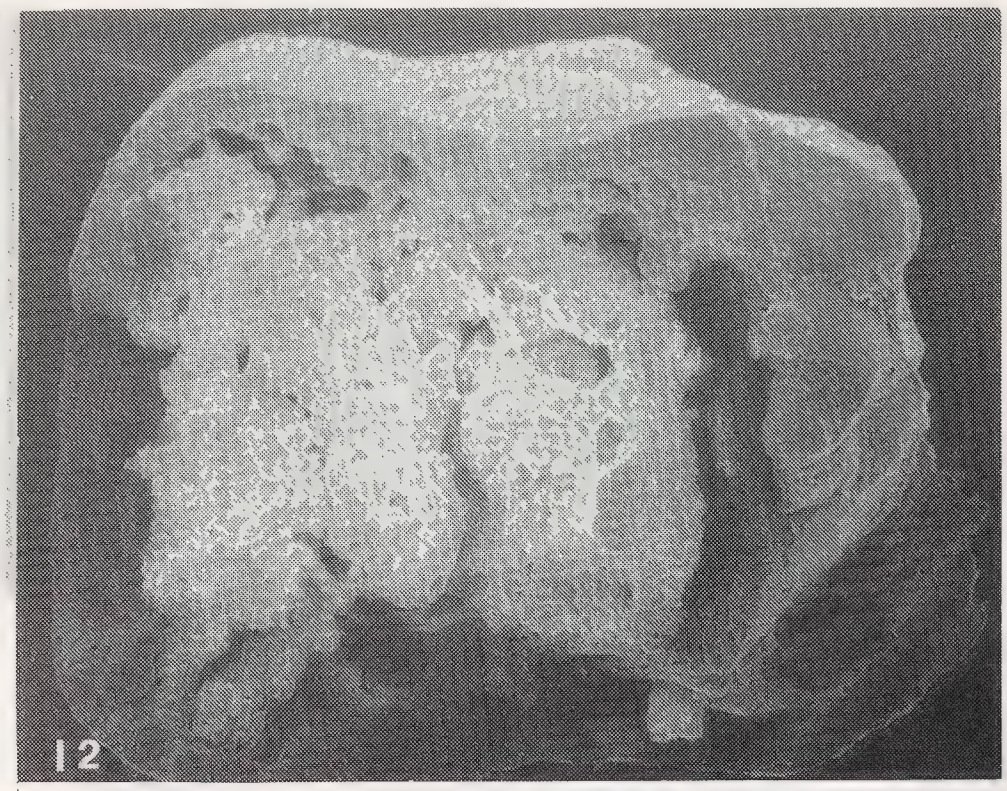


Fig. 11. *Rodriguezichthyes luedersensis* scale with part of orthodentine layer broken away to rounded outer surface of bone core. Fig. 12. *Rodriguezichthyes luedersensis* scale broken across base to show bone core and surrounding orthodentine. Bar scale represents 1 mm.

bones are oval in outline, slightly curved, and gently concave internally. Ornamentation of external surfaces consists of low, slightly divergent lines of small tubercles. Measurements of some large plates are: 36.4 x 22.0, 34.2 x 20.0 and 30.3 x 17.7 mm. The amount by which each plate overlapped its neighbor cannot be determined but, as *Rodriguezichthyes* presumably had five circumorbital plates as did other acanthodians, an eye diameter of more than 25 mm is suggested.

Pectoral girdle elements, represented only by perichondral bones are much rarer than fin spines. Perhaps 20 scapulacoracoids have been identified (Fig. 6). The proximal end of the scapular blade is slightly expanded in a thin ring but the termination is flat or slightly concave and appears ragged. The articulation with the suprascapula was cartilagenous, and the suprascapula may not have been ossified. No specimens with articulated procoracoids were found.

The scapulacoracoids recovered are mostly large but include one rather small and one moderate-sized specimen. It proved difficult to find points where comparable measurements could be taken. The greatest diameters of the proximal ends of the two largest scapular blades (suprascapulae missing) are 6.6 and 7.4 mm, whereas least diameters (constrictions) of blades between proximal and distal ends are 4.5 and 5.2 mm. The specimens all have narrow, shallow, longitudinal grooves on the distal portion that terminate in the hollow lateral to the procoracoid process and proximal to the subscapular fossa. The length of the scapulacoracoid from proximal end to the proximal margin of this hollow measures 19, 20 and 20 mm in three large specimens.

The scapulacoracoid of *Rodriguezichthyes* resembles that of *Acanthodes* more than that of any other acanthodian figured by Miles (1973). It closely resembles *A. wardi* Egerton and *A. lundi* (Zidek, 1980) in having the scapular blade constricted medially. *A. bronni* Agassiz (Miles, 1973) and *A. bridgei* (Zidek, 1976) have the scapular blade of more uniform diameter. The resemblance of the scapulacoracoid of *Rodriguezichthyes* to that of *Acanthodes* is close and perhaps the arrangement of fin spines was also similar.

One acanthodian braincase was found exposed in dorsal view with only the left side visible. It has been partly prepared but we are not able to describe it in detail at this time. Patches of the micromeric head scales form a single layer on the dorsal surface of the braincase. Patches of head scales were removed during preparation but some remain posterior to the occipital region, lateral and anterior to the left postorbital process, and lateral to the fontanelle depression. The scales are close

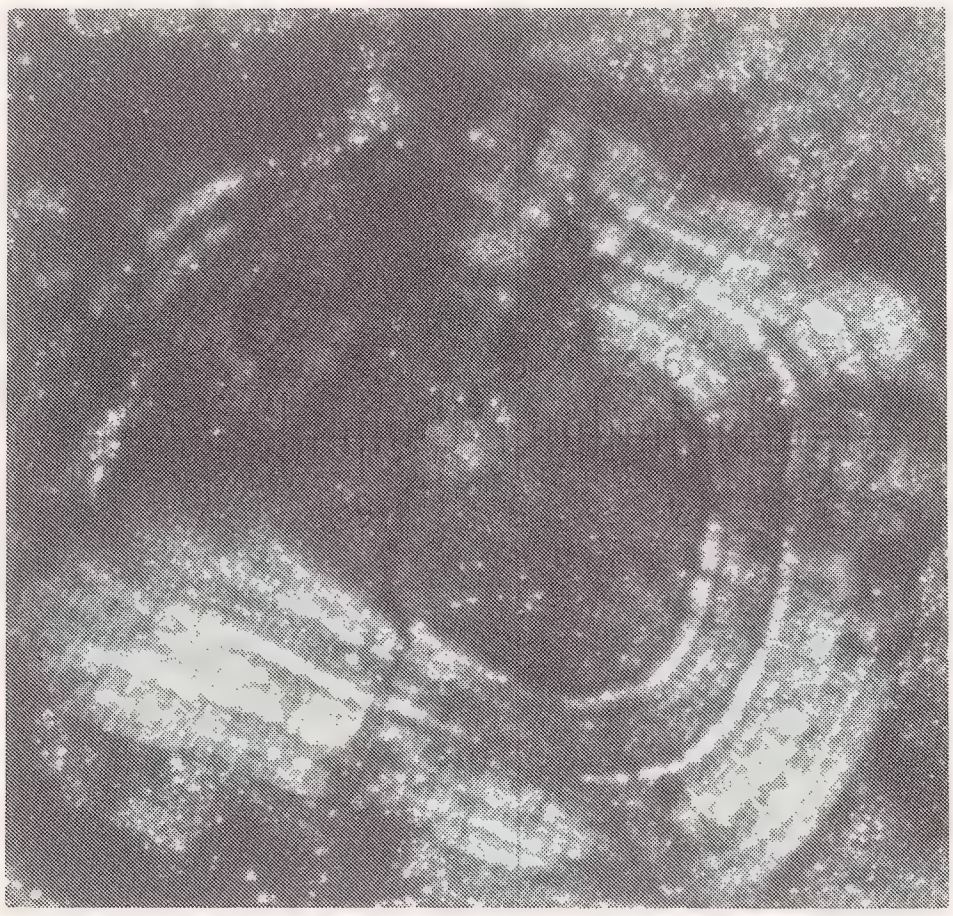


Fig. 13. Thin-section of *Rodriguezichthyes luedersensis* scale through upper part of scale base showing bone surrounded by successive layers of orthodentine. Bar scale represents 1mm.

together, but not in contact along their edges. They range from 0.2 to 0.6 mm in greatest diameter and vary widely in shape. Commonly they are flattened, irregular polygons with fluted margins but lacking ornamentation. Associated with the polygonal head scales are some of oval shape, while others have highly irregular outlines. We could not determine if the scales were originally in contact along their margins, or instead were separated to form a scale-studded expanse of skin.

The tesserae differ in detail from those described for other acanthodians. They most closely resemble those of *Acanthodes lundi* figured by Zidek (1980) but are larger, lack pit-like ornamentation, and have stronger fluting along the margins. Most acanthodian tesserae are thought to cover only the frontal region between and posterior to the orbits. Those of *Rodriguezichthyes* may have covered much of the head.

The squamation of *Rodriguezichthyes* appears to be unique among acanthodians. The scales are slightly elongated, rectangular in general outline at the crown, rather than square, and the posterodorsal margins are drawn out into sharp spines (Figs. 7, 8, 9). The outer layer is composed of laminae of a shiny enameloid. The scale base is thick and rough on its lower surface. Zidek (1976) noted that the crowns of the scales of *Acanthodes bridgei* overlapped the scale bases posteriorly. This is true in *Rodriguezichthyes* also. SEM photos (Figs. 7, 8, 9) show that each scale base is excavated posterodorsally and posteroventrally, and expanded anterodorsally and anteroventrally to accomodate the overlap (Figs. 7, 8). The underside of each scale bulges out to form a rounded, almost ball-like protuberance, as in some other acanthodian scales.

The histology of several acanthodian genera and species has been described. Brotzen (1934) pointed out that acanthodian scale histology is distinctive in all genera and some species of acanthodians. Moy-Thomas and Miles (1971) recognized two major types of acanthodian scales: the *Nostolepis*-type and the *Acanthodes*-type. Denison (1979) did not follow the usage of Moy-Thomas and Miles (1971), but agreed that the *Nostolepis* scale was unique in that it grew by periodic deposition of substance at the sides of the scale only (Gross, 1971). Other kinds of acanthodian scales grew by deposition of concentric layers that enclosed the entire scale, beginning with the scale primordium.

Acanthodian scales consist of a base and a crown. The scale base may be of cellular bone, with prominent lacunae (Orvig, 1967), orthodentine or mesodentine. Orvig described as mesodentine, dentine "which in addition to vascular canals . . . ., contains spaces for enclosed sclerocytes and network of ramified, intercommunicating, canaliculi-like processes issuing in part from the sclerocyte spaces and in part from the vascular canals." The scale base may contain complicated canal systems, patterns of Sharpey's fibers, or even pulp cavities. For figures of a variety of histologic patterns see Denison (1979).

Scale crowns usually consist of material that is harder and smoother than the scale base. Brotzen's mention of enamel in the scale crown has not been accepted by later workers, but most are vague about the substance that composes the scale crown. In most figured sections of acanthodian scales the crown composes half or more of the scale as seen in cross-section. The crown is sometimes considered to be of orthodentine or mesodentine.

The scales of *Rodriguezichthyes* (Fig. 10) are unique in several ways. A core of spongy bone (Figs. 11 and 12) is present, occupying a considerable volume of the center of the scale, and only outside of the core is the scale arranged in concentric layers of orthodentine with typical dentinal canals. The hard material of the scale crown occupies only a comparatively small area with part of the orthodentine of the scale base exposed when the scale is seen in dorsal view. The thick scale base and thinner crown are formed independently and meet along their edges, clam-shell fashion. The layers of the scale base surround the bony core (Figs. 11, 12) and the layers of the crown are almost flat.

The spongy bone core of the *Rodriguezichthyes* scale somewhat resembles the trabecular dentine described and figured by Peyer (1968), but, as seen in Fig. 14, the structure of the material appears to be of bone alone.

A horizontal section of a scale, beneath the crown (Figs. 13, 14), shows sharply delineated layers of orthodentine and the bone core when examined in transmitted light. Collagenous fibers are prominent but dental canals show only faintly. A thinner, vertical section examined in polarized light (Fig. 15) shows the dentinal canals plainly arranged as slight sinuous, unbranched, parallel tubules.

The scale crown of *Rodriguezichthyes* is dense and shiny, superficially resembling the ganoin of paleoniscoid scales when seen under low magnification. The contact of the dense crown material with the rough orthodentine is sharp (Figs. 16, 17). We simply term this layer "enameloid." It is formed by successive layers that cover completely the layer beneath (Figs. 18, 19). The edges of the enameloid roll over the layer beneath, and occasionally a layer of enameloid appears to be continuous with a layer of orthodentine, but this is an artifact; most simply join. In cross-sections the dense enameloid layers stand out from

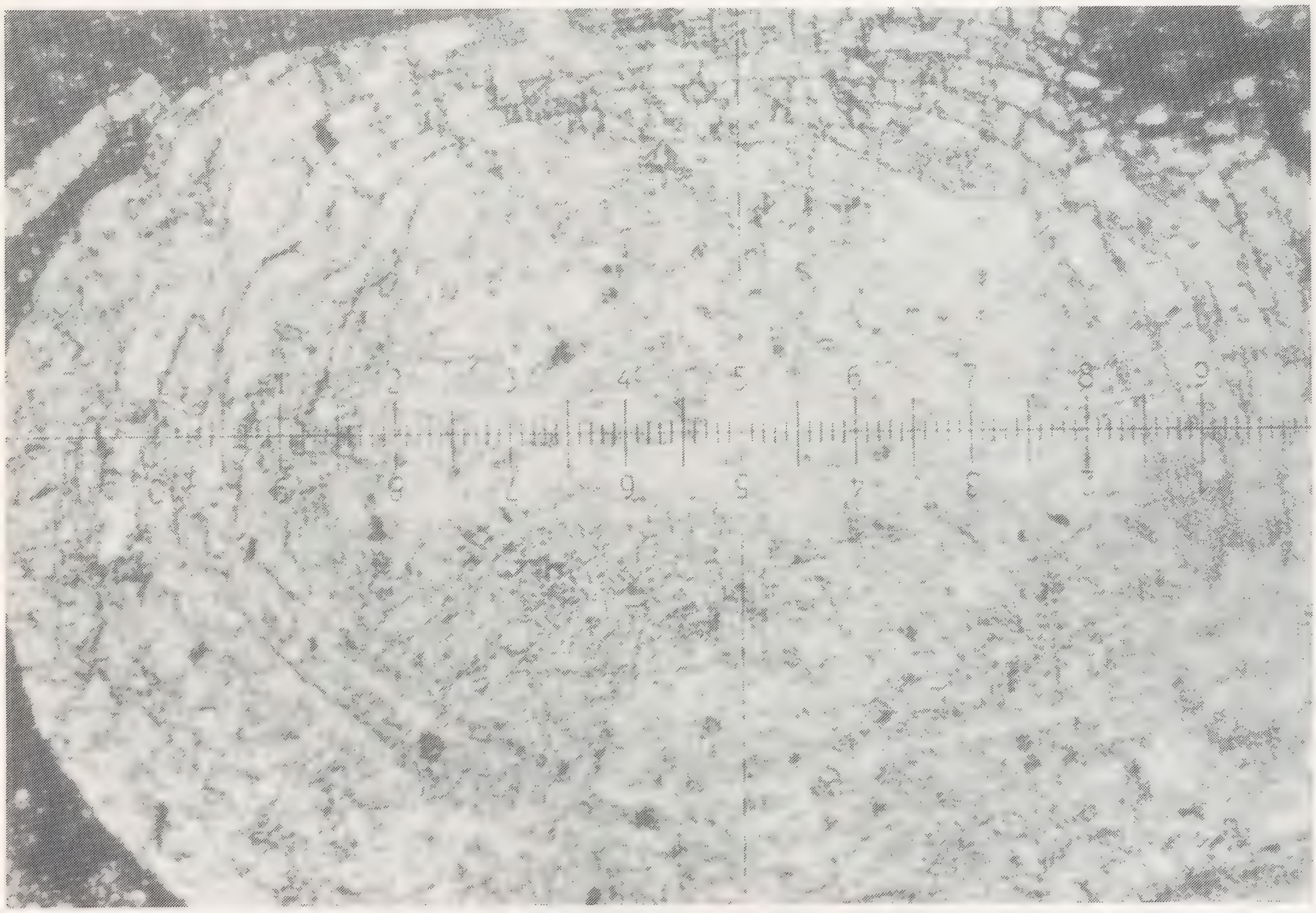


Fig. 14. Cross-section through *Rodriguezichthyes luedersensis* scale showing contacts of orthodentine layers and of bone core with orthodentine, lacunae, channels and collagenous fibers in bone core, collagenous fibers in orthodentine layers, and (upper right) enameloid layers separated in places "like bricks in a wall" by pore canals. Transmitted light. Scale represents 1 mm.

the less dense layers of orthodentine (Fig. 20).

Scanning electron micrographs (Figs. 21-24) show the nature of the enameloid substance. Highly magnified, the outer surface appears dimpled. In the center of each dimple is a pore leading directly downward as a pore canal. The pore canals terminate in cavities near the base of each enameloid layer. In thin-section pore-canals sometimes appear to separate the enameloid layers into short, vertical sections (Figs. 14), as bricks in a wall or cells in a cuboidal epithelium. The enameloid substance of the *Rodriguezichthyes* scale crown resembles, in some ways, Orvig's (1967) description of mesodentine, although no canaliculi-like structures were seen.

There is considerable variation in the size of the acanthodian scales in the fish layer. Larger scales are up to 1.4 mm in length, exclusive of the spine, whereas others are only 0.6 mm long. Most scales are slightly more than 1 mm long. Zidek (1975b) illustrates the difference in size between scales from the flank and ventral parts of a single acanthodian. We cannot say if the difference in sizes between the scales at Miller's Creek are due to difference in age of the fishes or parts of the body from which the scales were derived. A thin-section of a number of scales sectioned beneath their crowns shows roughly the same number of dentinal annuli on each.

V. SIGNIFICANCE OF *RODRIGUEZICHTHYES*

Acanthodians are the first fishes with true jaws to appear in the fossil record, appearing in the Lower Devonian and becoming extinct in the Lower Permian. Only the genus *Acanthodes* was previously thought to have survived into the Permian. All acanthodians from American Upper Pennsylvanian deposits that have been firmly identified to genus have been referred to *Acanthodes*.

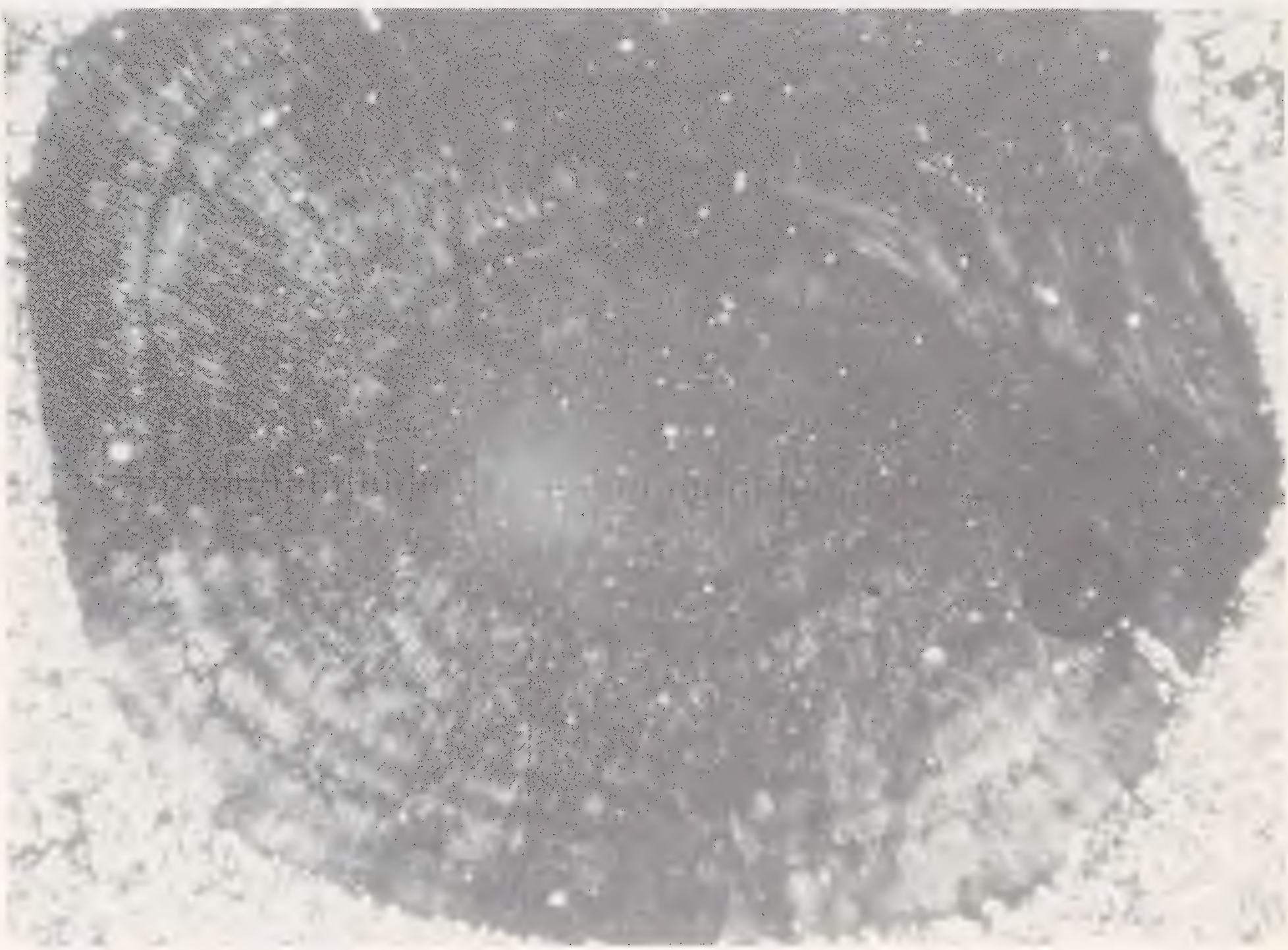


Fig. 15. Horizontal section through *Rodriguezichthyes luedersensis* scale in upper part of base, showing dentinal canals. Polarized light. Scale represents 1 mm.

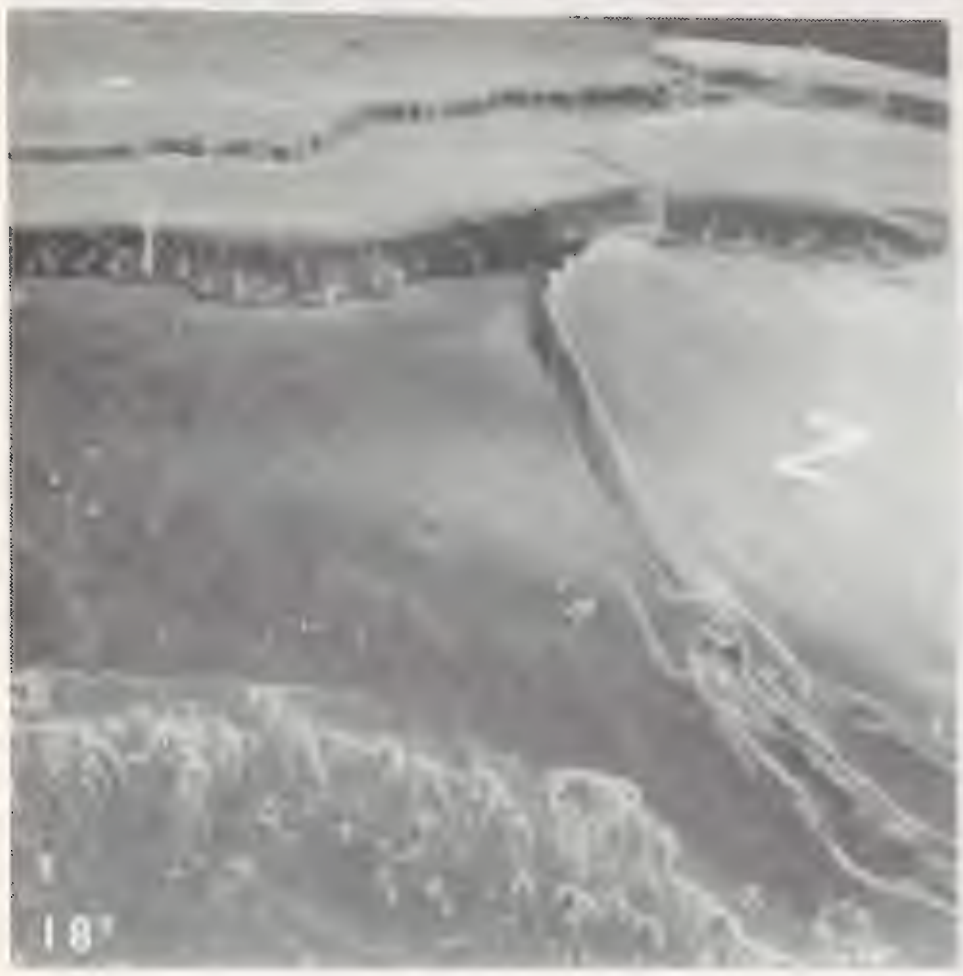


Fig. 16. *Rodriguezichthyes luedersensis* scale in lateral view. Outer layers of enameloid substance partly chipped away (fracture is accidental). At this magnification enameloid appears smooth and shiny (x 80).

Fig. 17. Enlargement of Fig. 16, showing how enameloid layers thin posteriorly, surface is dimpled, and pore cavities arranged at bases of enameloid layers. Note contact (lower right) of enameloid and rough orthodentine (x 250).

Fig. 18. Another view, showing dimpled surfaces of enameloid layers and contact with orthodentine of scale base (x 250).

Fig. 19. Enlarged view of enameloid surface of Figure 18, showing pore canal entrances at base of dimples in enameloid surface (x 570).

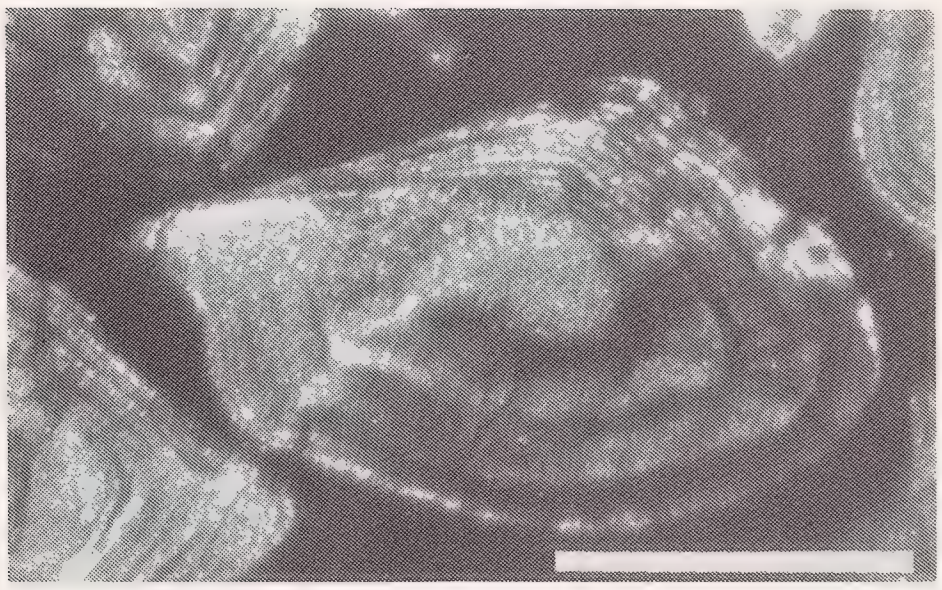


Fig. 20. Vertical section through *Rodriguezichthyes luedersensis* scale showing parallel enameloid (top) covering orthodentine scale base and bone core. Bar scale represents 1 mm.

Dunkle and Mamay (1956) termed a tiny, fingerling acanthodian from the Lower Permian of Texas *Acanthodes*. Zidek (1973) suggested the specimen might represent *Traquairichthyes* instead. Zidek later (1975a) referred freshwater acanthodian remains from Oklahoma to *Acanthodes*, and *Traquairichthyes* has not subsequently been mentioned. However, the discovery of *Rodriguezichthyes* shows that Permian acanthodians cannot automatically be referred to *Acanthodes*. *Rodriguezichthyes*, from the uppermost Wichita Group (uppermost Wolfcampian), is the youngest record of acanthodians other than the specimens of *Acanthodes* sp. from the Hennessey Group (Lower Leonardian) of Oklahoma. The presence of the enameloid layer on the scales may be a derived character.

VI. ASSOCIATED VERTEBRATES

Ctenacanthus cf. *C. amblyxiphias* Cope. – A ctenacanth shark spine measuring 240 mm was found. A shark with a spine of this length may have weighed more than 50 kg. Another smaller spine was found deeply imbedded in dolostone matrix. The length of this spine cannot be determined but also was of a large shark. Spines of similar large size were recovered from the Lueders Formation near Lake Kemp Dam (Dalquest and Kocurko, 1986).

"*Orodus*." – A single shark tooth of the *Orodus*-type was discovered by Dalquest and Emsoff (1977). The tooth is 6.5 mm wide and the sharply keeled crown rises gradually to the central cusp. The enamel is smooth. *Orodus* is a form genus for Paleozoic shark teeth with a low, elongated crown, a central cusp, and a deep groove or furrow separating the crown from the tooth base. Romer (1942) noted that such teeth might belong to any of several genera. *Orodus* is usually considered a hybodont shark. It is unusual that the only shark tooth discovered in the dolostone layers at either Lake Kemp Dam or Miller's Creek is of *Orodus*, while many fin spines, but no teeth, of *Ctenacanthus* were found.

"*Acrolepis*" scales. – The type of the genus *Acrolepis* Agassiz is *A. sedowicki*, known from complete specimens from European Permian deposits. The scales are thick and highly ornamented by elevated ridges of ganoin. The name "*Acrolepis*" has been used in Texas to describe paleoniscoid scales ornamented by elevated ridges, but it is doubtful that these belong to *Acrolepis*. They may be derived from several different kinds of paleoniscoids. Some may even be ridge scales of species with otherwise unornamented scales.

Progyrolepis tricessimilaris Dunkle, a paleoniscoid rarely mentioned in the literature, was described from a freshwater deposit in the Admiral Formation of Archer County, Texas. The type locality is about 60 km east of and three formations lower than the Miller's Creek site. The scales of *Progyrolepis* were described and figured by Dunkle (1964) and are of the *Acrolepis*-type (Aldinger, 1937). We doubt that the *Acrolepis*-type scales from the marine deposit at the study area are *Progyrolepis*, though it is possible.

Acrolepis-type scales are widespread in the channel conglomerates of the Wichita Group in north-central Texas but are not especially common. At most sites where paleoniscoid scales are abundant, less than one in ten scales is the highly ornamented type. Their glittery surfaces catch the eye and they may appear more common than they actually are. At the Miller's Creek site *Acrolepis*-type scales are almost as common as unornamented scales.

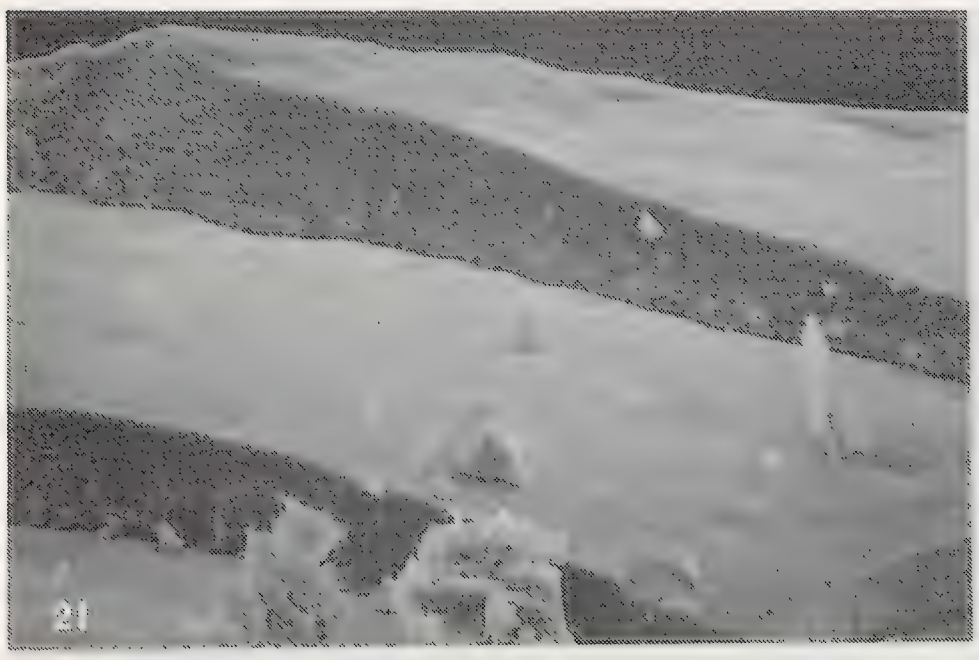
Unidentified paleoniscoids. – Numerous unornamented paleoniscoid scales are

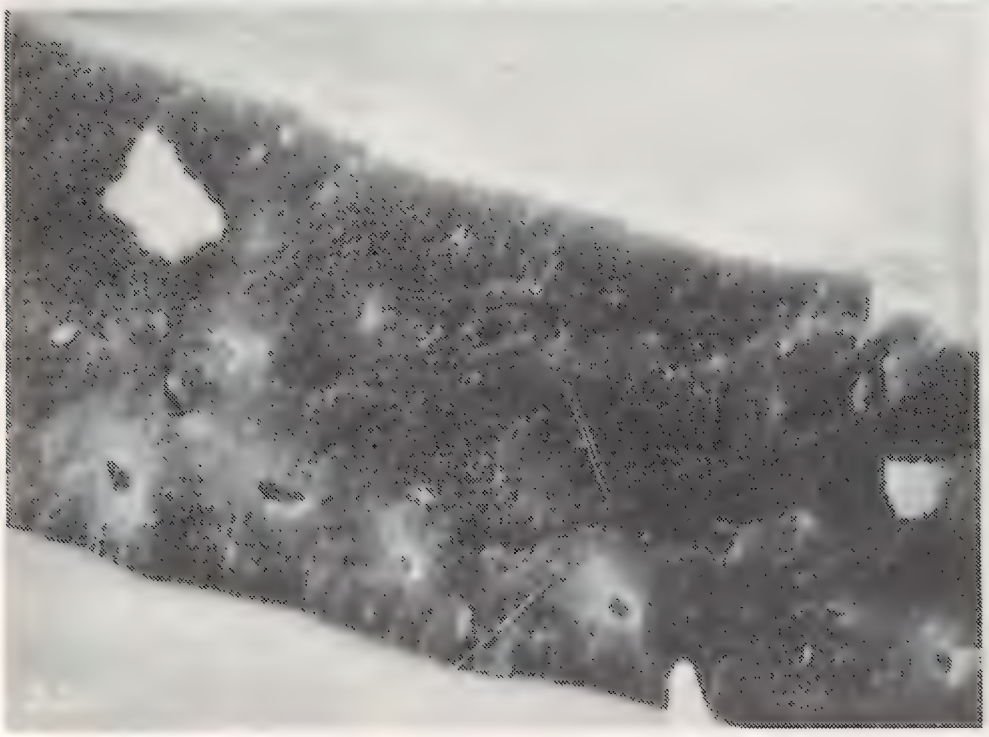
scattered through the matrix at Miller's Creek, varying in size and shape. The scales appear to be of normal proportions. None of the dorsoventrally elongated scales, typical of platysomids, were found. Platysomids were quite common in the marine Lueders Formation deposits at Lake Kemp Dam.

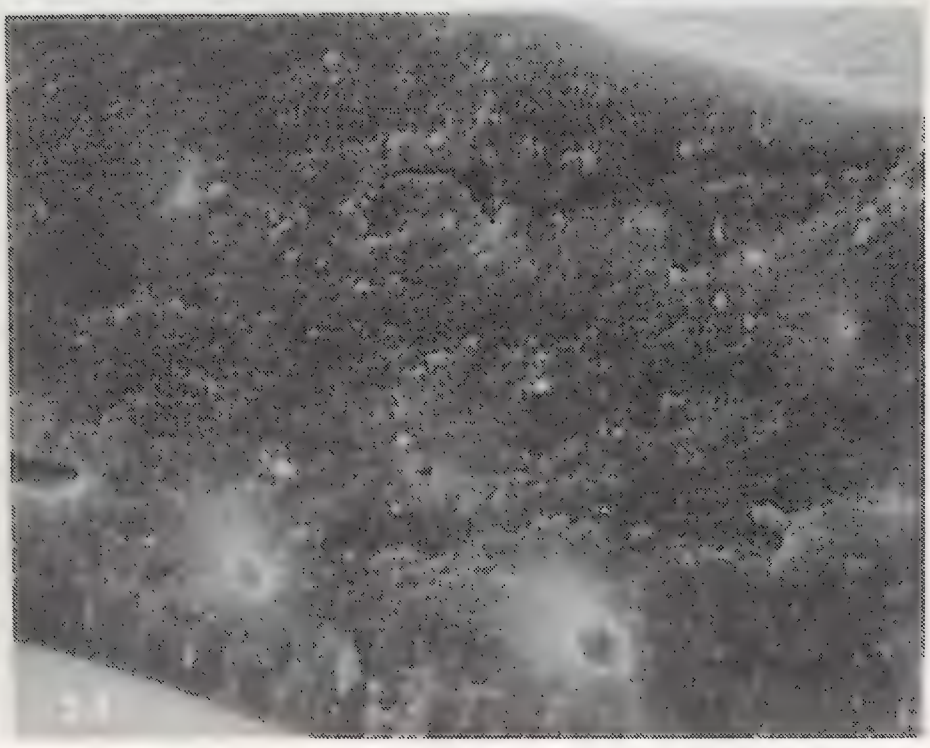
Phyllodont tooth plates (unidentified coelacanth?). – Numerous phyllodont tooth plates are scattered among the acanthodian fossils at the study area. They are often difficult to recognize in the massed acanthodian scales unless the regularity of arrangement of the teeth is seen. Individual teeth on the tooth plates are almost the size of the acanthodian scales. The tooth-plate bearer was probaby the second most common vertebrate present in the fauna. Tooth plates are outnumbered by isolated paleoniscoid scales but each paleoniscoid had hundreds of scales. Individual tooth-plate bearers must have outnumbered paleoniscoids.

Johnson and Zidek (1981) have given a detailed description of phyllodont tooth plates from Lower Permian formations of Texas and Oklahoma, including the Lueders Formation. Our specimens resemble those figured and described by Johnson and Zidek (1981).

Johnson and Zidek (1981) conclude that the Lower Permian phyllodont tooth plates are of paleoniscoid fishes, more specifically platysomids. However, since the tooth-plate bearer was a fairly common fish at the Miller's Creek site, if it were a platysomid we would have expected other remains, especially its characteristic scales, to be common. If scales were preserved in proportion to tooth plates, thousands of scales should have been present. Instead, platysomid scales are absent. We cannot conceive conditions in which platysomid tooth plates, but not the scales, would be preserved in the Miller's Creek deposit, particularly given the ascribed ecological setting.







Figs. 21-24. Successive enlargements (use spire-like shard for location) of a slightly oblique section through a layer of enameloid of a scale of *Rodriguezichthyes luedersensis*. Note basal position of pore cavities, pore canals (broken across to show rounded sections only), and dense nature of enameloid. 21 = x 580, 22 = x 1160, 23 = x 2660, 24 = x 4060.

In addition, size argues against a platysomid origin of the tooth plates. Johnson and Zidek (1981) found phyllodont tooth plates to range from 3-50 mm in length. The only platysomid named from the Lueders Formation is *Schaefferichthyes luedersensis* Dalquest 1966, and Johnson and Zidek suggested that some of the isolated phyllodont tooth plates belonged to this species. The holotype of *Schaefferichthyes luedersensis* measured only about 90 mm (standard length) and numerous other specimens seen or collected at the Lake Kemp Dam site were little, if any, larger. The smallest tooth plate from Miller's Creek is 20 mm in length, and the largest more than 40. Such tooth plates are too large for fishes usually less than 100 mm in length. *Schaefferichthyes luedersensis* may have grown much larger, of course, or a different and much larger platysomid may have existed, but thus far their fossils have escaped detection.

The tooth plate bearer could not have been an acanthodian, since early acanthodians had spiral whorls of marginal teeth and later acanthodians (*Acanthodes*) had no teeth. The Permian lungfishes, *Sagenodus* and *Gnathorhiza*, are freshwater fishes (*Gnathorhiza* was reported from a freshwater stratum of the Lueders Formation at Lake Kemp Dam by Dalquest, 1968) and their distinctive tooth plates are quite different from the phyllodont plates. The giant paleoniscoid *Luederia kempae*, described from the Lueders Formation at Lake Kemp Dam, is large enough (ca. 800 mm) to have had tooth plates as large as those at Miller's Creek. However, as in the case of platysomids, had *Luederia kempae* been the tooth plate bearer, large scales and dermal bones of its skull should have been present. Rhipidistian fishes were presumably extinct by the time the Lueders Formation was deposited (we do know of one specimen of *Ectosterorachis* collected in the Clyde Formation, only one formation beneath the Lueders Formation). Again, the thick, shiny scales and dermal bones of *Ectosterorachis* would be expected to be present in numbers if it had been the tooth plate bearer.

Johnson and Zidek (1981) argue against the tooth plate bearer being *Spermatodus pustulosus* Cope, the only coelacanth described from the Texas Permian. Earlier workers, notably the late A. S. Romer, considered tooth plates like those concerned here to belong to *Spermatodus*. According to Johnson and Zidek (1981: 532), *Spermatodus* has tooth-bearing parasphenoids and lacks tooth plates.

Our principal reason for rejecting paleoniscoids, platysomids, and rhipidistians as the bearer of tooth plates is the absence of the characteristic hard scales of these fish types in the Miller's Creek dolostone. Coelacanth fishes, however, had thin, cycloid scales that rarely preserve and would not be expected to be preserved in the Miller's Creek dolostone matrix.

Unidentified amphibians. – Several small pieces of highly sculptured bone were recovered that appear to be from amphibians. These bone fragments are not from fishes. Though they could be from small reptiles, their resemblance to amphibians is much closer. Amphibian remains would not be expected in a marine deposit but could have come from dead, bloated carcasses washed into the sea.

Dimetrodon? – A surprising discovery was the left maxillary of a large pelycosaur, probably *Dimetrodon*. The specimen is preserved as part and counterpart on slabs of orange dolostone. There is one long (60 mm) caniniform tooth, a space posterior to it for another, two small precanines and five postcanines. The specimen measures aproximately 165 x 120 mm.

Dimetrodon is the common, large carnivorous pelycosaur in Lower Permian deposits of Texas. The present specimen is not distinguishable from *Dimetrodon* (Romer and Price, 1940). *Dimetrodon* was a terrestrial reptile and if the maxillary belonged to that genus it probaby came from a bloated, floating carcass washed offshore, as suggested for the amphibians above. These specimens would also indicate deposition near shore.

Unidentified reptiles. – Three small, conical teeth were found that appear to be from reptiles. They are round in cross-section and lack the longitudinal grooves of labyrinthodont teeth. They are too small to belong to *Dimetrodon*.

VII. COMMENTS ON THE MILLER'S CREEK LOCAL FAUNA

The terrestrial and freshwater vertebrates of the Texas Permian have been studied and reported in great detail, but the marine vertebrates are less well known. Exposures of the Lueders Formation offer opportunity to study and compare the shallow water marine vertebrates from different places along the eastern margin of the Permian Mid-continental seaway. Two such faunas, the Lake Kemp Dam and Miller's Creek local faunas, are now available for comparison.

The Lake Kemp Dam site was a delta margin with marine mud intermittently covered with dark, freshwater sediments derived from shifting deltaic streams. The marine dolostones were intertidal deposits, often exposed to the air as indicated by mud cracks and footprints of large terrestrial amphibians and reptiles.

The fish-layer at the Miller's Creek site was probably a short distance offshore, and the dolostones formed in water less than a meter deep. The presence of a few remains of seemingly terrestrial amphibians and reptiles indicates a near-shore location. The presence of gentle currents is indicated by the orientation of acanthodian spines and scales. The vertebrate remains are probably largely of resident shallow-water fishes, and transient forms from deeper water.

In spite of their proximity (30 km), synchronology, and similarity in water depth, the Miller's Creek and Lake Kemp local faunas are strikingly different. At Lake Kemp Dam the fauna is dominated by paleoniscoids. Their disarticulated remains are ubiquitous, and scales and cranial elements are present in countless millions. Acanthodians are rare and represented by a single spine. At Miller's Creek the reverse is true; acanthodians are ubiquitous and paleoniscoids are relatively uncommon.

Even disregarding the tetrapods, freshwater paleoniscoids, and lungfish, the Lake Kemp Dam site has a much more diverse fauna. More kinds of paleoniscoids were identified at Lake Kemp Dam, because their remains are abundant and better preserved. Platysomids can be recognized even from isolated scales, but no platysomid scales were seen at Miller's Creek. Six bradyodont teeth were found at Lake Kemp Dam, but none were seen at Miller's Creek. The coelacanth from Lake Kemp Dam, questionably identified as *Spermatodus pustulosus*, may well be the same as the unidentified coelacanth (?) from Miller's Creek.

The cited differences between the two local fauna doubtless result from some important differences in ecological conditions. One would expect the shallow waters at the Miller's Creek site to have a more diverse fauna than the intertidal zone at Lake Kemp Dam, but this does not

TABLE 1. COMPARISON OF THE FAUNAS OF THE LAKE KEMP DAM AND MILLER'S CREEK

Lake Kemp Dam	Miller's Creek
Ctenacanthus cf. *amblyxiphias*	*Ctenacanthus* cf. *C. amblyxiphias*
Janassa sp.	
Rodriguezichthyes luedersensis?	*Rodriguezichthyes luedersensis*
Luederia kempii	
near *Lawnia taylorensis*	
"*Acrolepis*"	"*Acrolepis*"
Schaefferichthyes luedersensis	
Platysomus palmaris?	
unidentified paleoniscoids	unidentified paleoniscoids
Spermatodus pustulosus?	unidentified coelacanth(?)
Gnathorihiza serrata	
Trimerorachis sp.	*Trimerorarchis?*
Eryops megacephalus	
Diplocaulus magnicornis	*Dimetrodon* sp.
Dimetrodon?	

seem to have been the case. The great number of acanthodians at Miller's Creek cannot be accounted for at this time.

VIII. ACKNOWLEDGMENTS

The study was supported by a reserach grant from Midwestern State University. We are indebted to Dr. Fred Stangl, Midwestern State University, for advice and assistance in the course of our work and to Dr. Jeri Zidek for helpful suggestions concerning the manuscript. Much of the preparation was done by research assistants W. Fisher and A. Lucido. Some of the drawings were prepared by D. J. Lindsay. R. M. Carpenter aided in collecting in the field.

IX. LITERATURE CITED

ALDINGER, H., 1937, Permische Ganoidfische aus Ostgronland: Medd. Gronland, 102: 1-392.

BERMAN, D. S., 1968, Lungfishes from the Lueders Formation (Lower Permian, Texas) and the *Gnathorhiza*-lepidosirenid ancestry questioned: Jour. Paleontology, 42: 827-835.

BERMAN, D. S., 1970, Vertebrate fossils from the Lueders Formation, Lower Permian of north-central Texas: Univ. California Publs. Geol. Sci., 86: 1-39.

BROTZEN, F., 1934, Die Morphologie und Histologie der Proostea (Acanthodiden) Schuppen: Arkiv For Zoologi, 26: 1-27, 8 plates.

CUMMINS, W. F., 1890, The Permian of Texas and its overlying beds: Ann. Rept. Texas Geol. Surv., 1: 183-197.

CUMMINS, W. F., 1891, Report on the geology of northwestern Texas: Ann. Rept. Texas Geol. Surv., 2: 357-552.

DALQUEST, W. W., 1963, Large amphibian ischnites from the Permian of Texas: Texas Jour. Sci., 15: 220-224.

DALQUEST, W. W., 1966, An unusual paleonisciform fish from the Permian of Texas: Jour. Paleontology, 40: 759-762.

DALQUEST, W. W., 1968, Lungfishes from the Permian of Texas: Copeia, 1968: 194-197.

DALQUEST, W. W. and T. M. EMSOFF, 1977, Acanthodian remains from the Permian of Texas: Southwestern Nat., 20: 278.

DALQUEST, W. W. and M. J. KOCURKO, 1986, Geology and vertebrate paleontology of a Lower Permian delta margin in Baylor County, Texas: Southwestern Nat., 31: 477-492.

DENISON, R., 1979, Acanthodii: Handbook of Paleoichthyology, 5: 1-62.

DUNKLE, D. H., 1964, A new paleoniscoid fish from the Lower Permian of Texas: Jour. Washington Acad. Sci., 36: 402-409.

DUNKLE, D. H. and S. H. MAMAY, 1956, An acanthodian fish from the Lower Permian of Texas: Jour. Washington Acad. Sci., 46: 308-310.

EMSOFF, T. M., 1975, Permian vertebrates from a new site in the Lueders Formation, Baylor County, Texas. Unpublished MS Thesis Dept. Biology, Midwestern State University, pp. 1-25.

GROSS, W., 1971, Downtonische und dittonische Acanthodier-Reste des Ostseegebietes: Palaeontographica, Abt. A, 136: 1-82.

JOHNSON, G. D., 1979, Early Permian vertebrates. Unpublished Ph.D. Dissertation, Department of Geology, Southern Methodist University, Dallas, Texas, 653 p.

MAMAY, S. H., 1966, *Tinsleya*, a new genus of seed-bearing callipterid from the Permian of north-central Texas: U.S. Geol. Surv., Prof. Paper 523-E: E1-E5.

MILES, R. S., 1973, Articulated acanthodian fishes from the Old Red Sandstone of England, with a review of the structure and evolution of the acanthodian shoulder-girdle: Bull. British Mus. (Nat. Hist.), Geology, 24: 111-213.

MOY-THOMAS, J. A. and M. B. DYNE, 1938, The actinopterygian fishes from the Lower Carboniferous of Glencartholm, Eskdale, Dumfriesshire: Royal Soc. Edinburgh, Trans., 59: 437-480.

MOY-THOMAS, J. A. and R. S. MILES, 1971, Palaeozoic fishes, second edition. W. B. Saunders Co., 259 p.

OLSON, C. E., 1958, Fauna of the Vale and Choza: 14 summary, review, and integration of geology and the faunas: Fieldiana, Geology, Chicago Nat. Hist. Mus., 10: 397-448.

OLSON, C. E., 1975, Vertebrates and some problems of Permo-Carboniferous geochronology, pp. 98-103, *in* J. M. CYS and D. F. TOMMY (eds.), Permian exploration, boundaries, and stratigraphy: West Texas Geol. Soc. and Permian Basin Sect. Soc. Econ. Geol. and Mineral., Symposium and Fieldtrip Guide.

ORVIG, T., 1967, Some new acanthodian material from the Lower Devonian of Europe: Jour. Linn. Soc. (Zool.), 47: 131-153.

PEYER, B., 1968, Comparative Odontology. Univ. Chicago Press, 347 p., 87 Plates, 8 Color Plates.

READ, W. F., 1943, Environmental significance of a small deposit in the Texas Permian: Jour. Geol., 51: 473-487.

ROMER, A. S., 1936, Early history of the Texas Redbeds vertebrates: Bull. Geol. Soc. America, 46: 1597-1628.

ROMER, A. S., 1958, The Texas Permian Redbeds and their vertebrate fauna. Studies on Fossil Vertebrates, Essays Presented to D.

M. S. Watson, T. S. Westoll, ed., London, pp. 157-179.

ROMER, A. S. and L. I. PRICE, 1940, Review of the Pelycosauria: Geol. Soc. America, Spec. Paper 28: 1-538.

SCHAEFFER, B., and W. W. DALQUEST, 1978, A paleonisciform braincase from the Permian of Texas, with comments on the cranial fissures and the posterior myodome: American Mus., Novitates, 2658: 1-15.

SIMPSON, L. C.,1973, Occurrence of *Acanthodes* in the Lower Permian of Oklahoma: Oklahoma Geol. Notes, Univ. Oklahoma, 33: 191-196.

SIMPSON, L. C., 1974, *Acanthodes* and *Hybodus* in the Permian of Texas and Oklahoma: Jour. Paleontology, 48: 1291-1293.

WESTOFF, T. S., 1939, On *Spermatodus pustulosus* Cope, a coelacanth from the "Permian" of Texas: American Mus., Novitates, 1017: 1-23.

ZIDEK, J., 1973, Remarks on an acanthodian specimen from Texas: Oklahoma Geol. Notes, Univ. Oklahoma, 33: 201-202.

ZIDEK, J., 1975a, Oklahoma Paleoichthyology Part IV: Acanthodii: Oklahoma Geol. Notes, Univ. Oklahoma, 35: 135-146.

ZIDEK, J., 1975b, Some fishes of the Wild Cow Formation (Pennsylvania) Manzanita Mountains, New Mexico: New Mexico Bur. Mines & Mineral Resources, Circ. 135: 1-22.

ZIDEK, J., 1976, Kansas Hamilton Quarry (Upper Pennsylvanian) Acanthodes, with remarks on the previously reported North American occurrences of the genus: Univ. Kansas Paleo. Inst., Univ. Kansas, Paper 83: 1-41.

ZIDEK, J., 1977, An acanthodian shoulder girdle from the Lower Mississippi of Nova Scotia: Jour. Paleontology, 51: 199-200.

ZIDEK, J., 1980, *Acanthodes lundi*, new species (Acanthodii) and associated coprolites from the uppermost Mississippian Heath Formation of central Montana: Ann. Carnegie Mus. 49: 49-78.

REVIEWS

QUATERNARY GEOLOGY AND ENVIRONMENT OF CHINA, by Liu Tungsheng. Publishedby China Ocean Press, Beijing, China, and distributed by Springer-Verlag, Berlin, Heidelberg, New York, and Tokyo, 1985, x + 301 pp., illus., $69.50

Preparatory to the 11th INQUA Congress in August 1982, a symposium was held at Beijing in February 1982, summarizing the result of Quaternary research in China in recent years. The forty-two papers and eighteen abstracts presented here are from that symposium. These papers can be divided into six parts, Quaternary Stratigraphy (8 whole texts, 5 abstracts); Lithology and Genesis of Quaternary Deposits (10, 2); Quaternary Flora and Fauna (6, 3); Quaternary Paleogeography (13, 5); Prehistoric Man and his Material Culture (1, 1); and, Natural Resources of Quaternary Deposits (4, 2).

Much useful information is included, though the volume suffers from the unevenness characteristic of symposium compilations. However, it does present an overview of Quaternary research in China which is a valuable reference.

SEDIMENTARY AND EVOLUTIONARY CYCLES, edited by Ulf Bayer and Adolf Seilacher. Published by Springer-Verlag, Berlin, Heidelberg, New York, Tokyo, 1985, vi + 465 pp., illus., paperbound, $29.50

This is the first volume in a new series, Lecture Notes in Earth Sciences, published by Springer-Verlag and edited by Gerald M. Friedman. This work is the synthesis of a symposium held at Tübingen September 15-17, 1983. It presents twenty-two papers by thirty authors arranged in six sections: Sea-level Changes: General Consequences; Sedimentary Trends in Marginal Epicontinental Basins; Evolutionary and Ecological Replacements in Marginal Epicontinental Seas; Gastropod Evolution in Lakes; The Lower Hierarchy of Cycles: Spatial and Temporal Suibstrate Gradients; and, Ecological and Morphological Gradients. It is a worthwhile volume.

—H.C.S.

NOTES ON FOSSIL OCTOCORALS AND COMPARISONS OF SOME MODERN AND ANCIENT OCTOCORAL REMAINS

M. JOHN KOCURKO

MIDWESTERN STATE UNIVERSITY
WICHITA FALLS, TEXAS

ABSTRACT

Few published reports exist describing fossil octocoral remains, and most deal only with spicules or axial structures. The calcified holdfast has been greatly neglected. Observations of numerous holdfasts indicate features that may possibly be used for identification. Macrostructures such as overall morphology, surface striations or furrows, laminations, a central depression caused by the removal of the axis and an encrusting habit may all be used for gross identification. Microstructures, however, may prove to be much more helpful and may be a key to the identification of fossil holdfasts at the generic level. Study of these microstructures is still in the early stages.

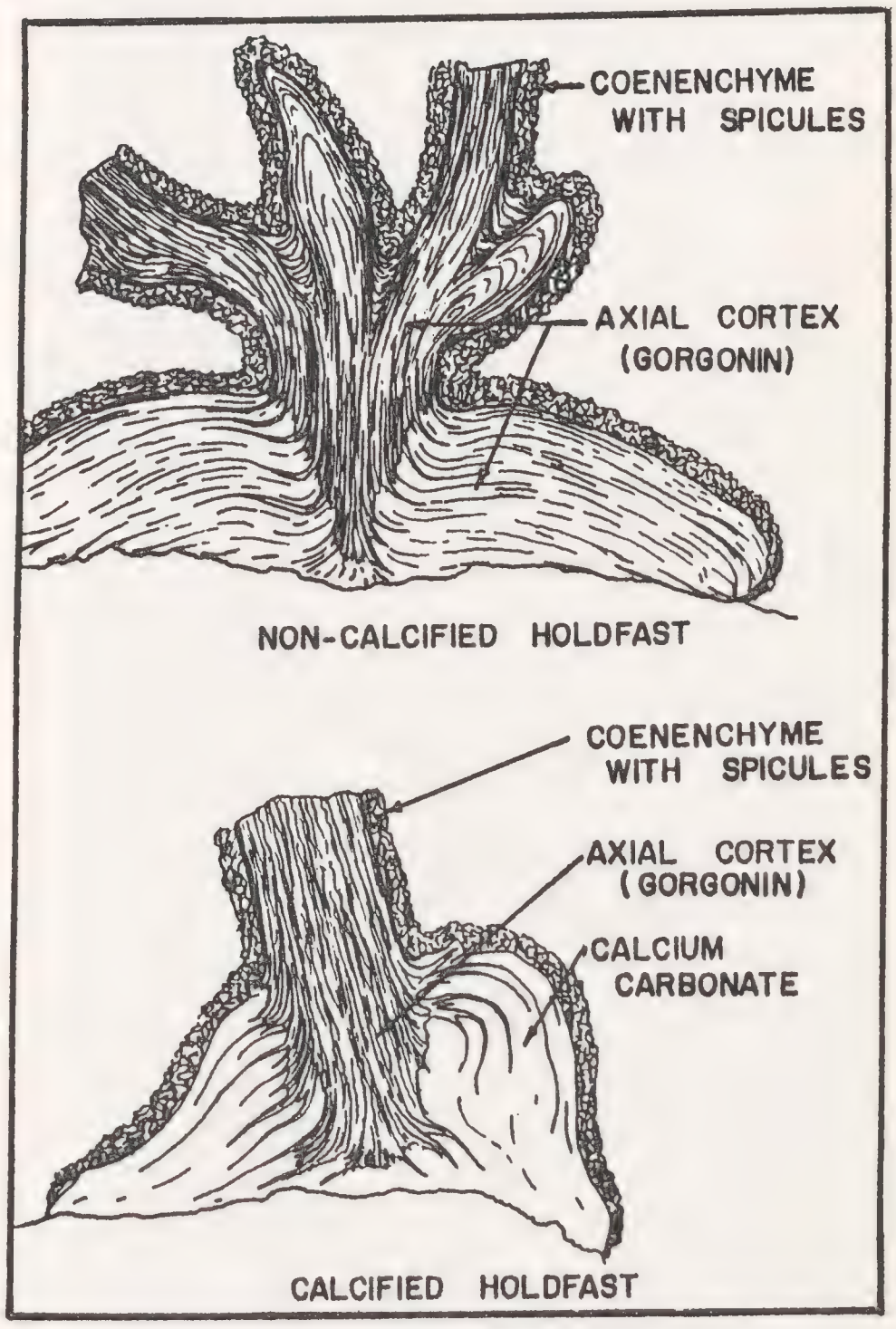
The dominant microstrucures are bundles of fibrous aragonite that form hemispheroidal mound-like features separated by thin laminae of gorgonin. The overall texture, size and configuration of the hemispheroids probably are usable for taxonomy, at least to the generic level.

INTRODUCTION

Few investigations have dealt with the problem of octocoral preservation. Colonial growth forms have been reported as fossils (*i.e.*, Williams, 1943; and Bayer, 1956), but often the specimens are poorly preserved and of questionable identity. Fossil octocorals also have been reported on the basis of spicule material and occasionally axial structures (Bayer, 1955; Giammona and Stanton, 1980; and Bengtson, 1981). According to Lindström (1978), the geologic range of octocorals is Lower Ordovician to Recent.

Information on modern octocorals is relatively abundant. The most significant taxonomic work is by Bayer (1961). Considerable work has also been done on growth forms, temperature tolerance, salinity tolerance, faunal distribution and chemistry of the colonial structures (Goldberg, 1973; Szmant-Froelich, 1974; Weber and Woodhead, 1972; and Spiro, 1971).

The purpose of this investigation is to compare modern and fossil octocoral structures and to point out that fossil octocorals may not be as rare as previously thought. For the purpose of studying fossil material, only a few parts of the colonial structure are significant. Other than rare impressions of soft parts, the calcareous spicule, the axial cortex and the calcified base or holdfast are important fossil remains.



Text-figure 1. Diagrammatic, longitudinal sections through non-calcified and calcified holdfasts.

EDITORIAL COMMITTEE FOR THIS PAPER:
JOHN W. WELLS, Ithaca, New York
WILLIAM C. WARD, University of New Orleans, New Orleans, Louisiana
F. M. BAYER, United States National Museum, Washington, D. C.

GENERAL MORPHOLOGY

Calcareous spicules are probably the most common remains found as fossils. They form in the coenenchyme and give structural support to individual polyps and the entire colony. Numerous types of spicules can be found in any one particular colony and these are generally used to establish the taxonomy of the organism. Fossilized spicules can be distributed throughout sediment and mixed with remains of other octocorals. The identification of a particular fossil species on the basis of these spicules is usually dificult, if not impossible. Bayer (1956) states the problem clearly: "Very possibly the seemingly hopeless problem of identifying such isolated spicular remains has prompted many investigators to ignore them when observed in samples." In some cases, however, where particular species have diagnostic spicule types, taxonomy may be established. This identification is usually based on a single spicule or a small group of spicules.

In addition to difficulties with identification, the problem is compounded by the dificulty of actually finding the spicules when their presence is known in a sample. The small size of most spicules causes many problems in separating and collecting specimens. Spicules are also often destroyed during diagenesis by dissolution or by the action of boring organisms. Original spicular material in most specimens is high-magnesium calcite (as opposed to low-magnesium calcite), and its lack of stability under certain conditions can affect the preservation of fossil material.

In addition to spicular material, other octocoral structures can be preserved. Several authors have reported the existence of preserved axial structures (Hickson, 1938; Bayer, 1956; and Giammona and Stanton, 1980). The Isididae are probably the most common forms preserved, because of extensive calcification of the axis. The Primnoidae and Ellisellidae always have cal-

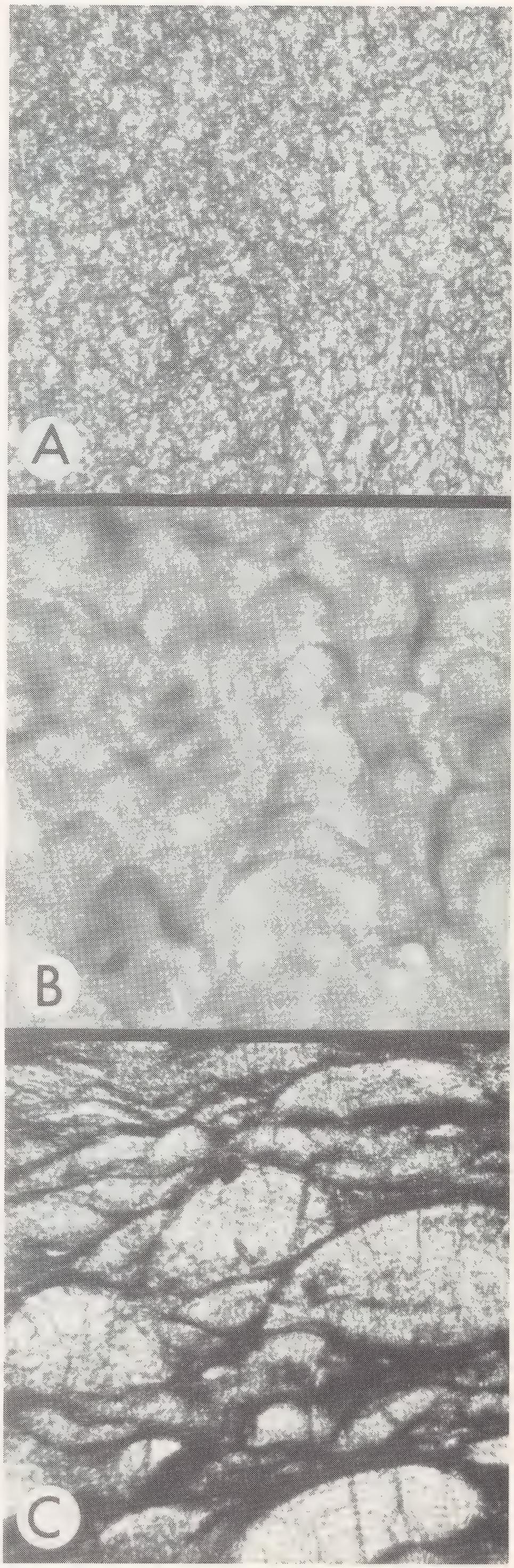
Text-figure 2. Photomicrographs of hemispheroidal structures in (A), *Plexaurella dichotoma* (a plexaurid); (B), *Pterogorgia anceps*, and (C), *Pterogorgia citrina*. B and C are gorgonids. The figure width represents 275 micrometers, and all figures represent longitudinal sections.

cified axes and are occasionally fossilized. However, these families are not the only groups that can be found as fossils, as will be pointed out later.

In most octocorals the axial structure is brown, stiff, horny material. Chemical analysis of modern axial structures indicates a composition of collagen-like protein. This axial material, often referred to as "gorgonin," has incorporated spicules and granules of calcium carbonate (Szmant-Froelich, 1974). In cross-section the axis appears to be partially concentric layers of gorgonin.

The third part of the colonial structure that can be preserved is the calcified base. Text-figure 1 is a diagrammatic longitudinal section through a typical octocoral holdfast. Although calcification does not occur in all octocorals, the holdfasts and axes of the families Plexauridae, Primnoidae, Ellisellidae, Isididae, Chrysogorgiidae and Gorgoniidae are commonly lithified. Calcification usually occurs between the coenenchyme and the axial cortex. Most of the calcification occurs in the basal structure of the colony and increases the attachment strength of the organism. With age, calcification may progress upward around the lower portion of the axis. Calcium carbonate crystallization may be promoted by the presence of carbonate granules incorporated in the gorgonin, as mentioned earlier, and these granules may act as nucleation sites for crystal growth. X-ray analysis of the calcified holdfast indicates an aragonite composition in all of the specimens examined in this study, but Bayer (1978, personal communication) stated that the composition may be aragonite or calcite, and mineralogy probably has nothing to do with taxonomy.

It should be noted that the presence of calcification in the holdfast probably has no relationship to the relative age of the colony. Small, young colonies may have



Text-figure 3. These photomicrographs indicate the diversity of microstructure configuration from one genus to another. (A), *Plexaurella grisea*, figure width represents 275 micrometers. (B), Enlargement of (A), width represents 44 micrometers. Note stacked hemispheroids. (C), *Eunicea tourneforti*, width represents 275 micrometers. All figures represent vertical sections. Both species are plexaurids.

calcified material as well as older specimens. The size and age of the colony do affect the amount of calcification and, thereby, the size of the holdfast. A moderately-sized holdfast may weight between 150 and 200 gm and measure 100 mm in diameter. Plate I shows several examples of typical holdfasts. Fracturing around the axis (pl. 1, figs. 1 and 2) is characteristic of most holdfasts and is probably related to tensional forces developing during growth of the coloy or post-mortem dessication. The calcified portion of the holdfast shows a typical laminated carbonate structure (pl. 1, figs. 3 and 4) when the axial cortex is removed by post-mortem decomposition. Striations are also common features on the calcified surface (pl. 1). The position of the small grooves is related to the overlying longitudinal coenenchymal canals.

Petrographic examination of modern calcified holdfasts indicates a diversity of microstructures. At present, the significance of these structures to taxonomy is uncertain, but general distinctions can possibly be made at the generic level. Three different microstructure forms, representing two genera and three species, can be observed in Text-figure 2. The petrographic configuration within the holdfast is dictated by the arrangement of hemispheroids or quadraspheroids of aragonite-crystal bundles. These hemispheroids are usually separated by thin sheets of gorgonin that appear as laminae. The size and arrangement of the crystal bundles vary from species to species. Typically the hemispheroids are constructed of fibrous crystals radiating from a nucleation site.

The three species in Text-figure 2 are shown at the same magnification. The moderately-sized hemispheroids of the Gorgonids, *Pterogorgia anceps* (2B) and *P. citrina* (2c), are easily distinguishable from the minute structures found in the Plexaurid, *Plexaurella dichotoma* (2A). The small elongations or stylolite-like projections seen in *P. dichotoma* are stacked hemispheroids. This is only discernible under higher magnification. Text-figure 3 indicates the diversity of size and shape of these microstructures. Hemispheroids from *Plexaurella grisea* average 12 micrometers in width and are typically stacked (Text-figs. 3A and B). Structures typical of *Eunicea tourneforti* often exceed 200 micrometers in width and are usually surrounded by thick laminiae of gorgonin. A comparison can also be made between *Plexaurella dichotoma* (Text-fig. 2A) and *P. grisea* (Text-fig. 3A). Both photomicrographs are at the same scale. Stacked hemispheroids of *P. dichotoma* are almost twice as wide as those found in *P. grisea*. These comparisons may be of taxonomic significance; however, numerous additional samples need to be examined to determine if this size differentiation is usable as a taxonomic tool.

FOSSIL OCTOCORAL

As mentioned above, examples of fossil octocoral material have been reported in the literature. Most of these reportings deal with spicules or occasionally axial structures. The most significant fossil material, the holdfast, has been neglected by most investigators. The problem seems to be the lack of recognition or simply misidentification.

Morphology of both fossil and modern holdfasts and axial segments are generally correlatable but recrystallization of fossil material can cause difficulty in distinguishing internal structures. For this reason identification at the generic level is difficult and often impossible.

The fossil octocorals presented below were collected in six different areas and range from Eocene to late Pleistocene in age. The specimens are grouped according to location.

Location 1 . . . Middle Pleistocene, Limón, Costa Rica. Octocoral axes,

---

PLATE 1

1, 2. Modern calcified holdfasts with well-developed tensional cracks around the axes. (1 = X 2.3, 2 = 2.2)

3, 4. Holdfasts showing the central depression and laminated carbonate structure. (3 = X 2.2, 4 = X 1.2)

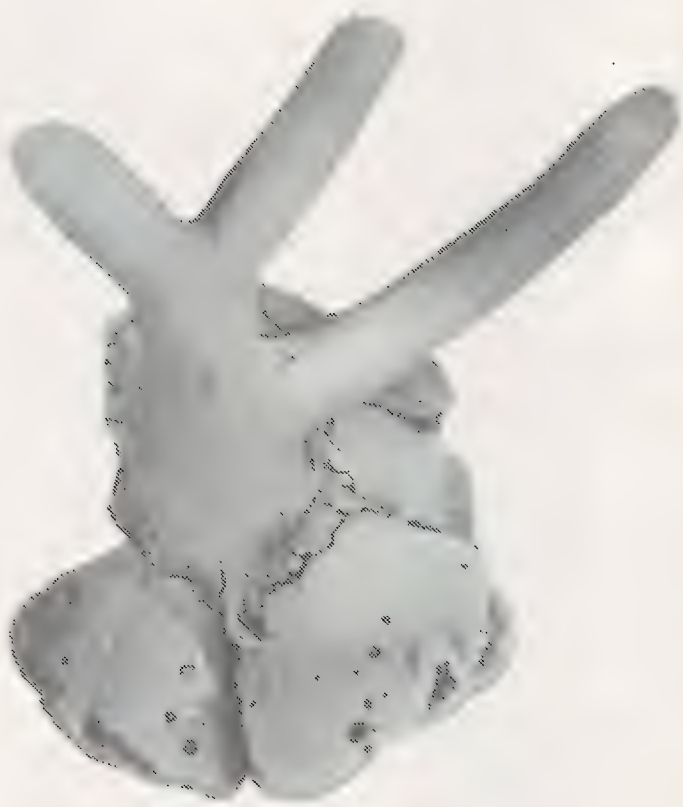


PLATE 1

spicules and holdfasts were collected from the Moín Formation near Limón, Costa Rica. Several examples of well-preserved axial cortex or calcified gorgonin (pl. 2) were found in poorly lithified grey shales and siltstones. The Moín Formation is composed of alternating sequences of reef/shelf carbonates and clastics (Taylor, 1973). Initial deposition of clastics occurred in a water depth of approximately 50 m, as evidenced by studies of foraminifers (Taylor, 1973) and molluscs (Vokes, 1978, personal communication). The formation contains an abundant fauna including mollusca, hermatypic corals, arthropods, worms, echinoids and foraminfers. The middle part of the formation is highly bioturbated and most of the burrows are preserved by sediment infilling. Small, low-relief, coralline patch reefs are also present in the formation, with the dominant coral types *Porites*, *Diploria*, and *Montastrea* (Taylor, 1973). These reefs probably supplied the hard substrate needed for most octocoral growth.

Plate 2, figures 1 to 7 are typical examples of octocoral structures from the Moín Formation. To date, only one calcified base has been found and the identification is uncertain. However, internal microstructures, such as the hemispheroidal pattern, indicates similarity to modern forms of *Plexaurella grisea*. Identifications of the other specimens, based on internal features (*i.e.*, hemispheroid structures), are impossible, as these features are seldom observable in branch fragments. A photomicrograph (pl. 2, fig. 4) shows the typical laminated gorgonin found in branch materials. Macrostructures indicate that fragment 1 probably belongs to the isidids; whereas, fragments 2 and 3 are either primnoids or ellisellids. Without more characteristic structures, identification of these specimens at the generic level would be, at most, a guess. The specimen shown in Plate 2, figures 5 and 6 is an axial segment with numerous small branches. Petrographic analysis indicates a structure composed of calcified gorgonin with no hemispheroidal patterns. Based on morphology similarities with modern specimens, the sample is tentatively identified as *Plexaura* sp.

Location 2 . . . Pleistocene, Florida Keys, Florida. The recrystallized remnant of a large holdfast (pl. 3, fig. 1) was found in a recent excavation on Cudjoe Key. Internal structures have been destroyed by recrystallization and, as a result, identification of this specimen is questionable. Based on general shape and size (100 mm in diameter), the specimen resembles typical holdfasts of gorgonids and plexaurids. Reference should be made to Plate 1, figures 3 and 4 for similar modern specimens.

The Florida sample exhibits the typical laminated carbonate structure as described earlier. The depression in the center of the specimen was formed by decomposition of the gorgonin axis.

Location 3 . . . Upper Pleistocene, northeastern Yucatan Peninsula, Mexico. This calcified holdfast (pl. 3, figs. 2 and 3) was found in shoreface storm deposits (Ward, 1978, personal communication). The specimen is well-preserved and exhibits numerous typical features found in most calcified holdfasts: 1) striated surface; 2) laminated carbonate; 3) central depression formed by removal of gorgonin; 4) encrusting nature, as seen in cross-sectional view; and 5) hemispheroid structures observed in thin-section. The sample was sectioned before photographing and as a result only one-half of the holdfast is

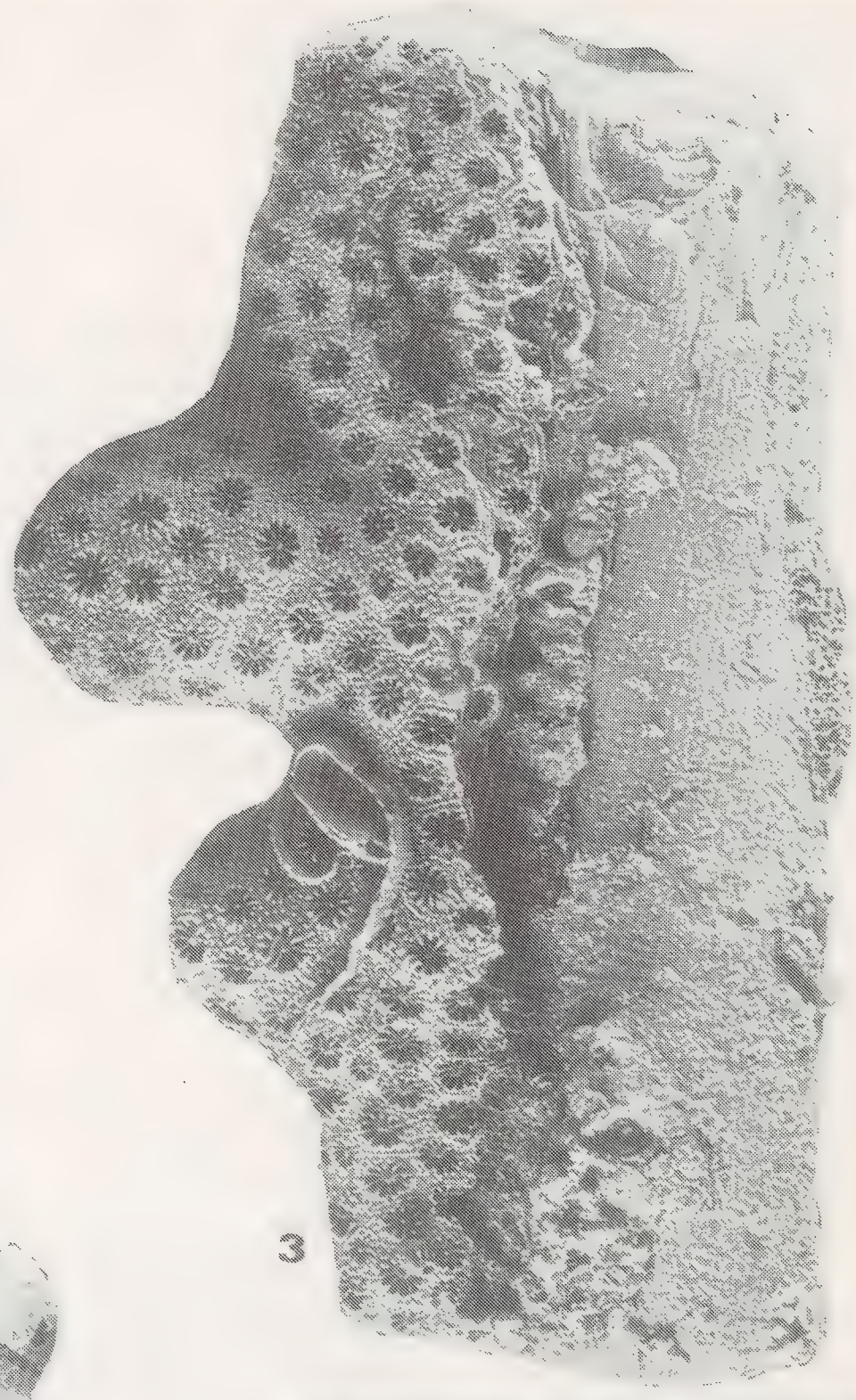
PLATE 2

1-3. Branch fragments of octocorals. These stems are composed of calcified gorgonin. (1 = X 2.4, 2 = X 2.2 and 3 = X 2.4) Specimen 3 is partially encrusted by a scleractinian coral.
4. Cross-sectional view, in thin-section, of the calcified axis figured as (3). (X 16.4)
5, 6. Calcified axis with surface striations. Note the attachment points of smaller branches (*Plexaura* sp.) (X 2.4)
7. Small calcified holdfast encrusting a mudstone concretion. (X 1.6)

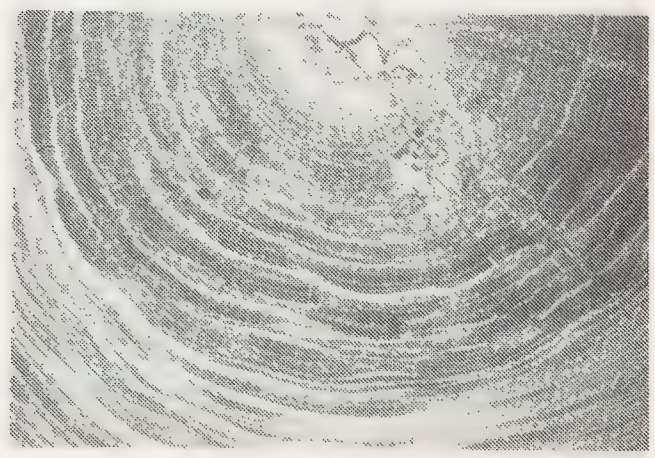
Note: All samples were collected from the Moín Formation, Limón, Costa Rica.

1

2



3



4

5

6

7

PLATE 2

available. Based on the observable features, primarily hemispheroid structures, this specimen is tentatively identified as *Pterogorgia*. Internal structures closely resemble features found in modern examples of *Pterogorgia anceps*.

Location 4 . . . Plio-Pleistocene, Bowden Formation, Jamaica. Lamb and Beard (1972) established the age of the Bowden Formation at the Plio-Pleistocene boundary on the basis of foraminifers. This conflicts with previous work by Woodring (1925) who placed the formation in the Middle Miocene. Woodring describes the Bowden as an ". . . imperfectly consolidated gravel . . . in a marly matrix . . . with perfectly preserved fossils . . ."

The holdfast collected from the Bowden Formation (pl. 3, figs. 4 and 5) is indeed well-preserved and is one of the better holdfasts in the collection. Both macro- and microstructures are observable even though some recrystallization to calcite has occurred. Based on the size of the center depression the axial cortex of the colony is estimated to be 25 mm in diameter. This would indicate that the living colony was rather large and stout. Microstructures within the base most clearly resemble those of the modern genus *Plexaurella*.

Location 5 . . . Lower Oligocene, Red Bluff Formation, Mississippi. Holdfasts from the Red Bluff Formation (pl. 4, fig. 1) are typically small (10 to 15 mm in diameter) and are found attached to marine mudstone nodules. Spicules also can be found in the sediment, although none are diagnostic enough for a firm identification.

The Red Bluff holdfasts, though small, exhibit typical octocoral features found on modern calcified bases: 1) grooved or furrowed surface; 2) laminated carbonate; 3) central axial depression; and 4) encrusting habit. There is no doubt that these specimens are octocorals, but because of extensive recrystallization further identification at this time is speculative. Only remnants of gorgonin material and hemispheroids are observable in thin-section (pl. 4, fig. 2).

Location 6 . . . Upper Eocene, Danville Landing Beds, Jackson Group, Louisiana. These holdfasts (pl. 4, figs. 3 and 4) closely resemble specimens from the Red Bluff Formation (Location 5). They are also small, encrusting forms attached to mudstone nodules. Based on general appearance they are probably of the same genus as the Oligocene samples, but again recrystallization has destroyed most of the microstructures.

CONCLUSION

Many of the specimens presented in this report may represent extinct genera. Due to the lack of work on microstructures within the holdfast it would be premature to establish new names for these fossils. At the present time it is sufficient to simply relate the fossil forms to modern counterparts.

Recognition of the holdfast as octocoralline is significant, as its presence in a formation can give an investigator more insight into paleoecologic conditions. Confusion of the holdfast structure with other organisms could also be an important problem. The laminated nature, encrusting habit, and presences of organic layers (gorgonin) might easily be confused with stromatolitic structures.

Examination of microstructures within the bases of modern octocorals indicates that different species may have different configurations of hemispheroids (aragonite bundles). Size, shape and position within the holdfast seem to be significant. At this time, a considerable amount of work needs

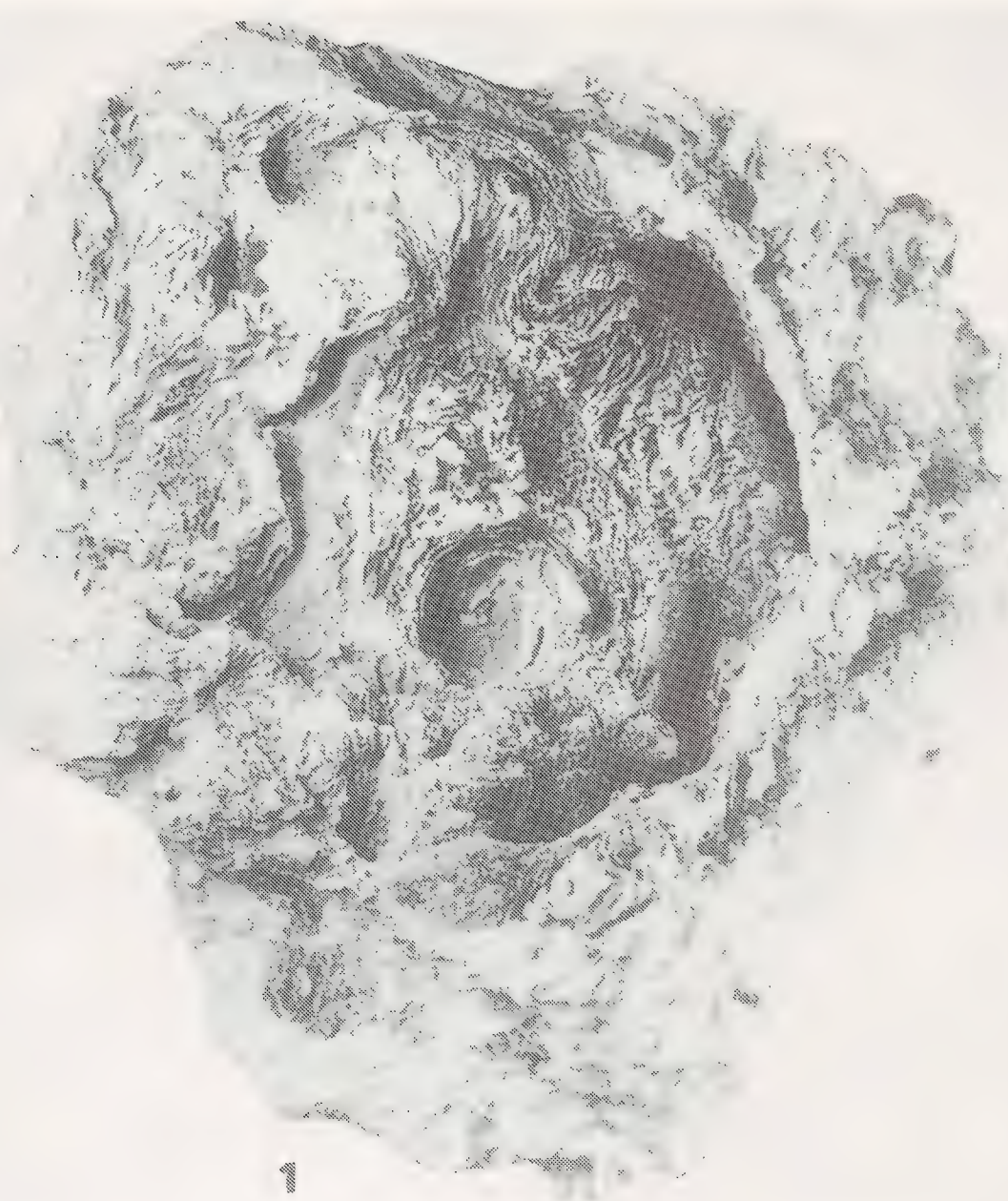
---

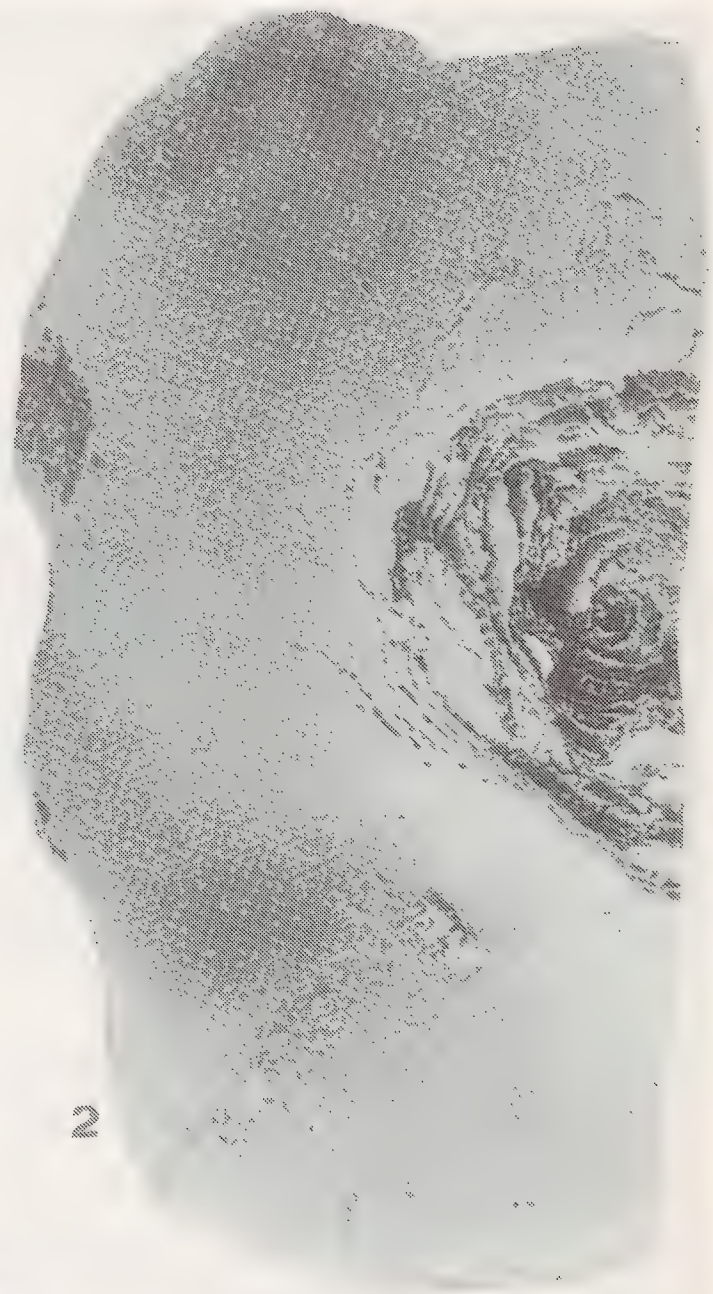
PLATE 3

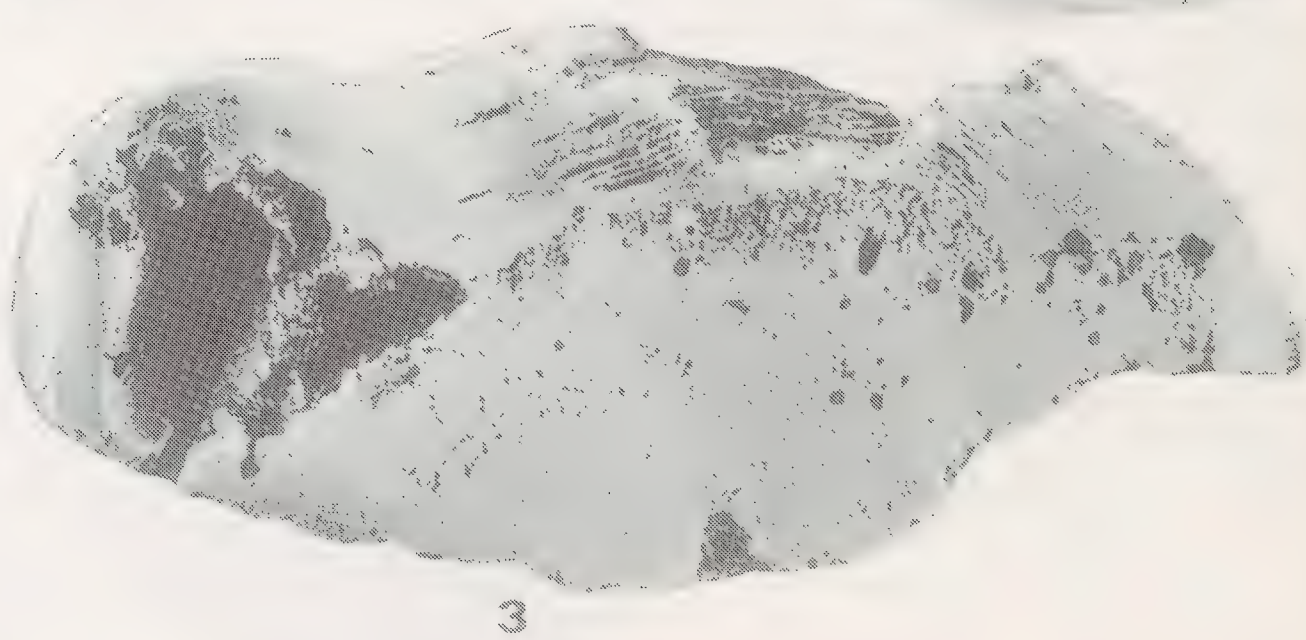
1. Large calcified holdfast from the Florida Keys. Recrystallization has destroyed the microstructure but most macro-features are easily observable. (X 0.9)

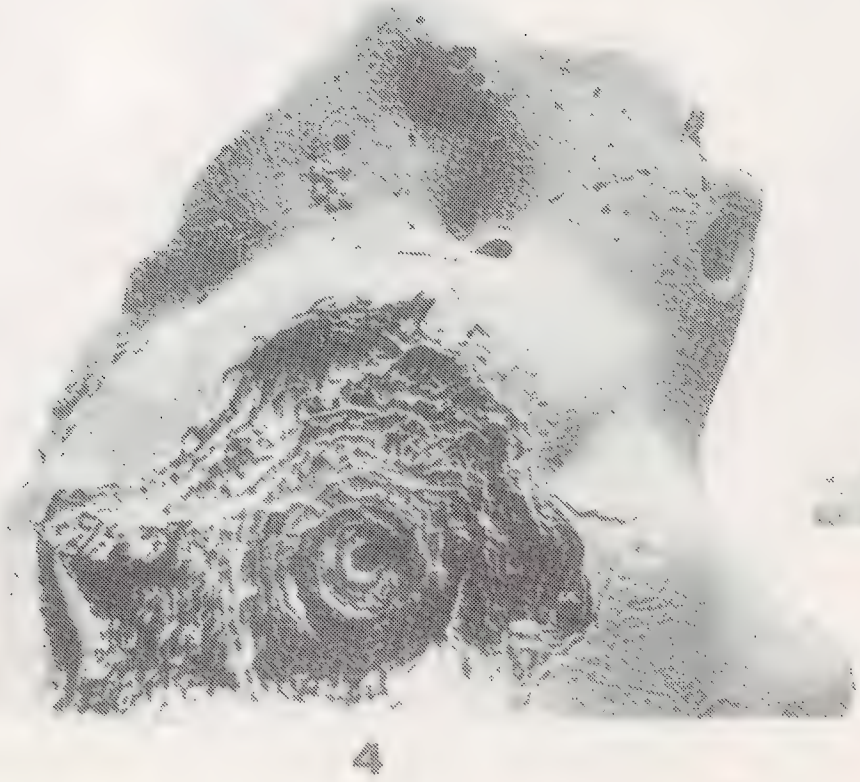
2, 3. Well-preserved holdfast from the Yucatan Peninsula. Note lamination and surface striations. (X 2.1) Figure 3 represents a vertical section.

4, 5. Calcified holdfast from the Bowden Formation. The central depression is particularly well-developed. (X 1.2)









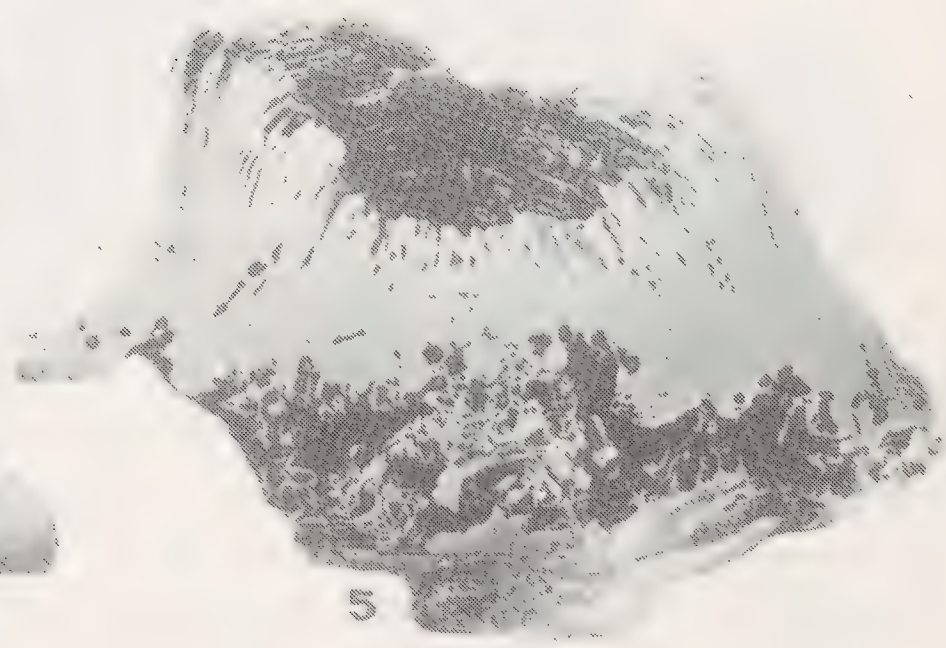


PLATE 3

to be done to further evaluate the significance of these microstructures to the taxonomy of octocorals. It is likely that fossil octocorals are not as rare as previously thought and perhaps more emphasis should be placed on their usefulness as environmental indicators.

ACKNOWLEDGMENTS

Thanks are extended to Emily and Harold Vokes, Tulane University, for sample material and to William C. Ward, University of New Orleans, for his contribution to the collection.

REFERENCES CITED

BAYER, F. M., 1955, Contributions to the nomenclature, systematics and morphology of the Octocorallia: Proc. United States National Museum, v. 105, p. 207-220.

BAYER, F. M., 1956, Octocorallia, p. 166-231, *in* R. C. MOORE (ed.), Treatise on Invertebrate Paleontology, Part F, Geol. Soc. Amer. and University of Kansas Press.

BAYER, F. M., 1961, The shallow-water Octocorallia of the West Indian region. Martinus Nijhoff, The Hague, 364 p.

BENGTSON, S., 1981, *Atractosella*, a Silurian alcyonacean octocoral: Jour. Paleontology, v. 55, p. 281-294.

GIAMMONA, C. P., and R. J. STANTON, 1980, Octocorals from the Middle Eocene Stone City Formation, Texas: Jour. Paleontology, v. 54, p. 71-80.

GOLDBERG, W., 1973, Ecological aspects of salinity and temperature tolerances of some reef-dwelling gorgonians from Florida: Caribbean Jour. Sci. v. 13, p. 173-177.

HICKSON, S. J., 1938, An alcyonarian from the Eocene of Mississippi: Jour. Washington Acad. Sci., v. 28, p. 49-51.

LAMB, J. L., and J. H. BEARD, 1972, Late Neogene planktonic foraminifers in the Caribbean, Gulf of Mexico, and Italian stratotypes: University of Kansas Paleontological Contributions, Art. 57 (Protozoa 8), 57 p.

LINDSTRÖM, M., 1978, An octocoral from the Lower Ordovician of Sweden: Geologica et Palaeontologica, v. 12, p. 41-47.

SPIRO, B. F., 1971, Ultrastructure and chemistry of the skeleton of *Tubipora musica* Linné: Bull. Geol. Soc. Denmark, v. 20, p. 279-284.

SZMANT-FROELICH, A., 1974, Structure, iodination and growth of the axial skeletons of *Muricea californica* and M. *fruticosa* (Coelenterata: Gorgonacea): Marine Biology, v. 27, p. 299-306.

TAYLOR, G. D., 1973, Geology of the Limón area, Costa Rica: Ph.D. thesis, Department of Geology, Louisiana State University, Baton Rouge, Louisiana, 116 p.

WEBER, J. M., and P. M. J. WOODHEAD, 1972, Stable isotope ratio variations in non-scleractinian coelenterate carbonates as a function of temperature: Marine Biology, v. 15, p. 293-297.

WILLIAMS, J. S., 1943, Stratigraphy and fauna of the Louisiana Limestone of Missouri: U.S. Geol. Survey, Prof. Paper; 203, 133 p.

WOODRING, W. P., 1925, Miocene mollusks from Bowden, Jamaica: Part 11, Gastropods and discussion of results: Carnegie Inst. Washington, Publ. no. 385, 564 p.

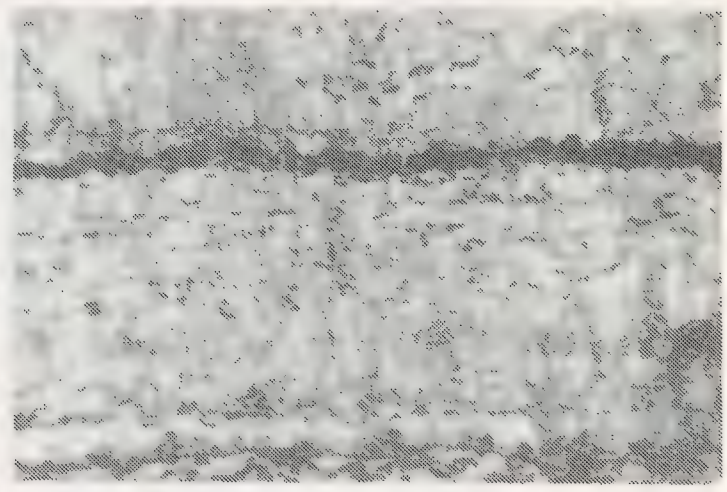
October 12, 1988

PLATE 4

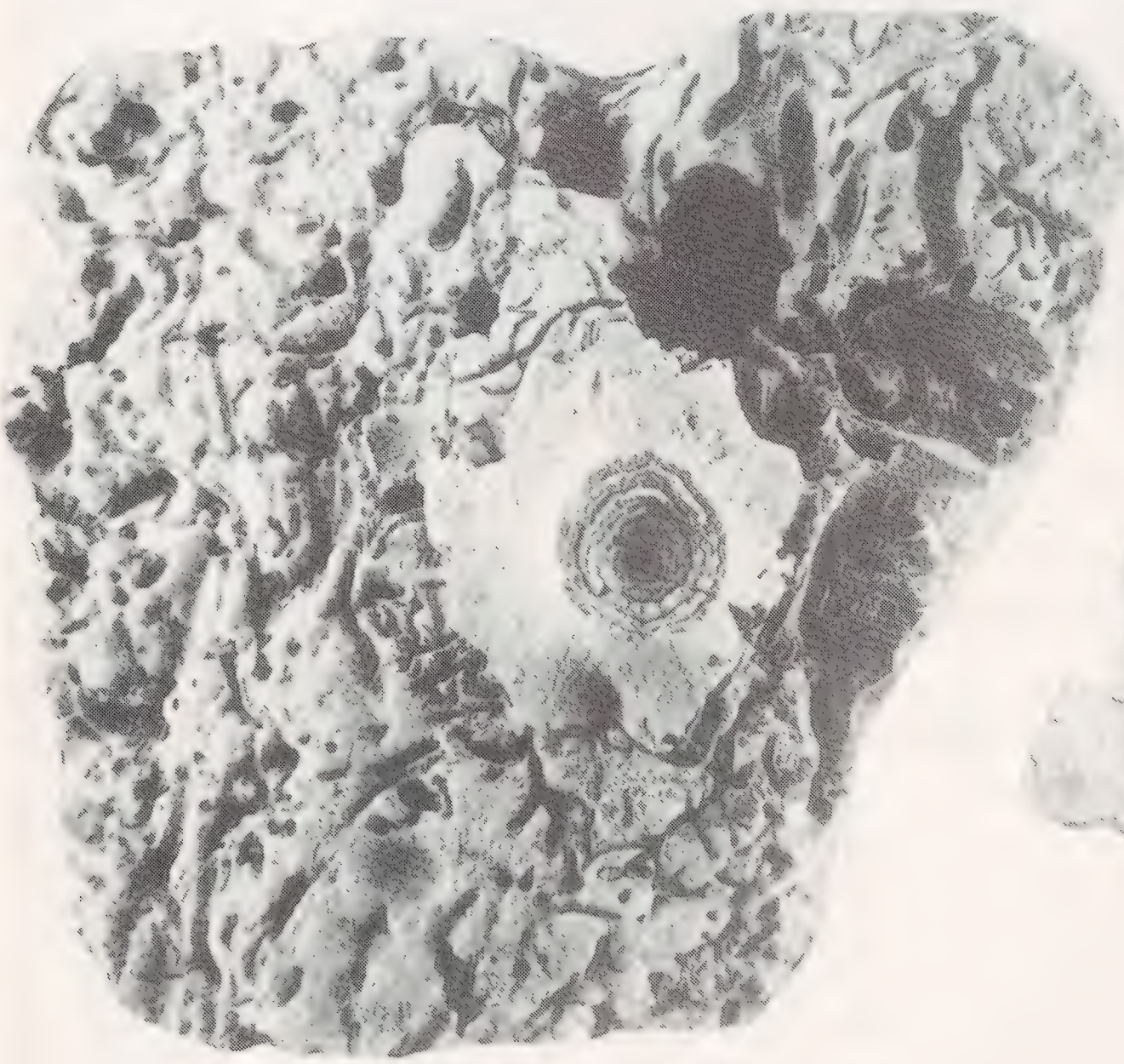
1. Six individual holdfasts attached to a mudstone nodule. Macro-features are easily observable. (X 2.3) (Red Bluff Formation).
2. Recrystallization of the holdfasts in figure 1 has destroyed most of the microstructure. There is, however, some remnant gorgonin. (X 25) The figure represents a vertical section.

3, 4. Calcified holdfasts of Eocene age (Danville Landing Beds). (3 = X 2.9, 4 = 2.2)

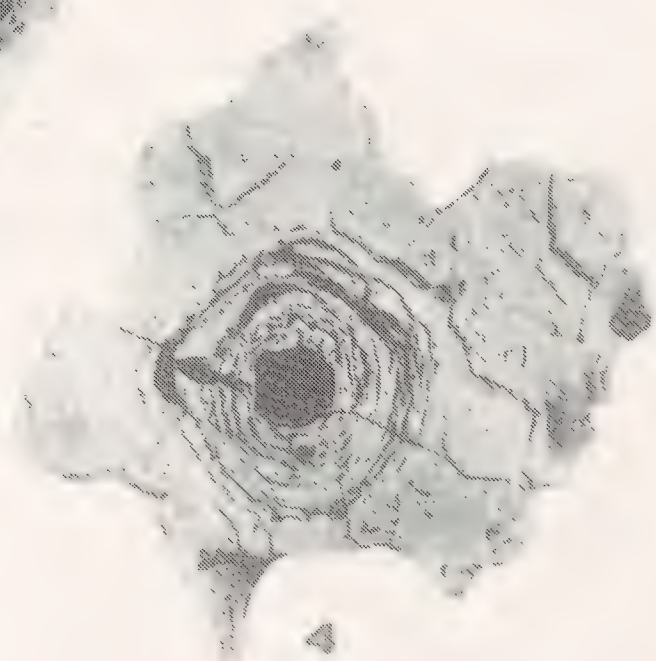
1



2

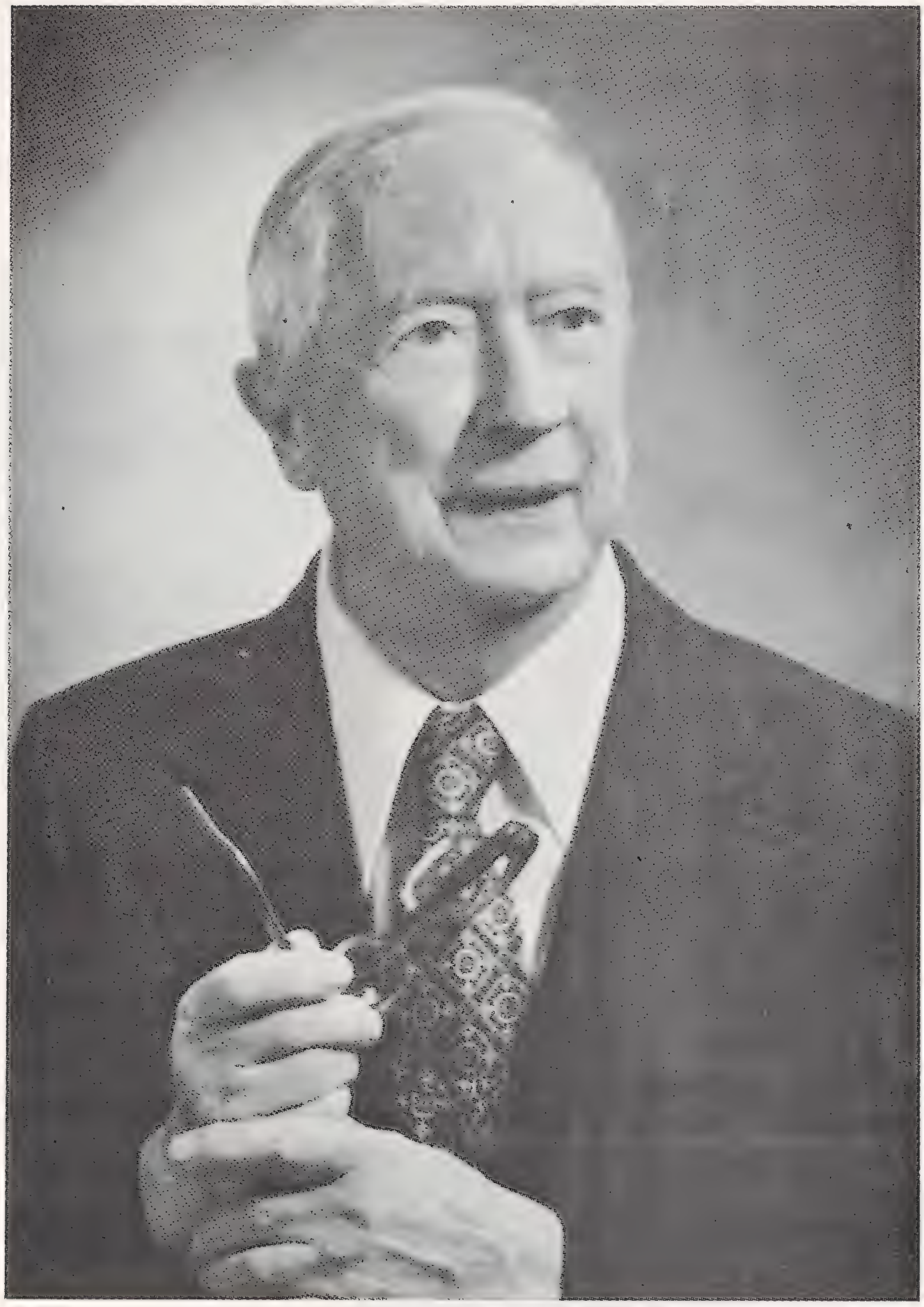


3



4

PLATE 4



VIGNETTES OF COASTAL PLAIN GEOLOGY

AXEL ADOLF OLSSON
(1889-1977)

As a graduate student of G. D. Harris, at Cornell University, Axel Olsson made the first of many Latin American expeditions in 1916, when he assisted Carlotta Maury in her exploration of the Mio-Pliocene strata of the Dominican Republic. Before finishing his dissertation he took a job with the Sinclair Oil Company and began work in the Gulf Coastal Plain, pioneering the use of Foraminiferida in oil geology in Texas, Oklahoma, and Louisiana. In 1922 he was sent to Peru and for the next thirty years he looked for oil and fossils with equal success. Upon retirement in 1952, he settled in Coral Gables, Florida, and for the rest of his life pursued the stratigraphy and paleontology of southern Florida. His major works include monographs on the Tertiary and Recent faunas of Peru, Ecuador, Costa Rica, Panama, and Florida. (*From* D. R. Moore, 1978, Nautilus)

SOME MARINE PELECYPOD FAMILIES AND GENERA THAT ARE RELICTS OR LIVING FOSSILS

DAVID NICOL

*GAINESVILLE, FLORIDA**

The book *Living Fossils* (1984, edited by Eldredge and Stanley) was recently reviewed by Thomson (1987). He pointed out that the 32 contributors to this book had different ideas as to what a living fossil is. Some of the contributors were of the opinion that a living species that can be traced back to the Cretaceous would be a living fossil. Others would consider a lineage that has changed little through a great span of time (bradytely) would be considered a living fossil group. Still others would consider those lineages that were once much more widespread and diverse than they are now as living fossils. These groups are now represented by one or a few species with endemic or disjunct geographic distributions and may be phyla, classes, orders, families, or genera (Nicol, 1981). The term used for this phenomenon is a relict. In this essay I will briefly review nine groups of pelecypods that are relicts and can be considered living fossils. These nine groups have a good geologic record as verified by the *Treatise on Invertebrate Paleontology* (R. C. Moore, ed., 1969, 1971) and *Tertiary Faunas* (Davies, Vol. 1, 1971).

The relict family Cucullaeidae was common and diverse during the Jurassic and Cretaceous. The family is now represented by a single variable species of *Cucullaea* that lives in the Indo-West Pacific region (Nicol, 1950b).

The Gryphaeidae can be considered a relict family in Recent seas. The family is now represented by one subfamily, the Pycnodonteinae, with six species that occur in either the Tropical or North Warm Temperate zones (Harry,1986). Two subfamilies and two tribes are extinct, and this family was much more diverse in the Jurassic and Cretaceous seas (Nicol, 1984).

The Trigoniidae are commonly considered living fossils. The family comprised many genera and had a world-wide distribution during the Jurassic and Cretaceous but is now represented by a single genus with five or possibly six species (Stanley, *in* Eldredge and Stanley, eds., 1984). The unusual aspect of the geographic distribution of the Trigoniidae is that they have been confined to the seas around Australia throughout the Cenozoic.

The Fimbriidae is a relict group that was widespread in warm seas during the Jurassic and Cretaceous. The family became less diverse and its geographic range contracted during the early Tertiary, and it now is represented by two living species of *Fimbria* that occur in the Western Pacific (Nicol, 1950a). The Fimbriidae is a conservative stock; the Cretaceous species look much like the Recent ones.

Astarte is a relict genus with a markedly disjunct geographic distribution. About six species live in Boreal and Arctic waters, and one tiny rare species lives in the Antarctic region. The Astartidae is poorly represented in Recent seas (Boss, 1971) as compared with the family during the Jurassic and Cretaceous.

The Arcticidae is a relict family that was represented by many genera and species during the Jurassic and Cretaceous, but *Arctica* has one living species confined to the Boreal North Atlantic (Nicol, 1951a). Relatively few species and genera of the Arcticidae occur in Tertiary strata.

Glossus is a relict that is represented by a single species that lives from the Mediterranean Sea northward to Norway and Iceland (Nicol, 1951b). It was more widely distributed and diverse in the Tertiary.

Meiocardia is a relict with a disjunct geographic distribution. It is presently living in the Caribbean and the Gulf of Mexico and also in the Philippines, East Indies, and Hawaii. There are possibly four or five living species, but this genus was more diverse and widely distributed during the Tertiary. *Glossus* and *Meiocardia* are not closely related because the hinge teeth, shell shape, and ribbing are quite different between the two genera (Davies, 1971).

Pholadomya, which is found today as a single rare species in deep water in the Caribbean, is a notable relict. Cox and Newell (*in* Moore, ed., 1969) mention that the small-sized species in the Antarctic do

*Mailing address:
Box 14376, University Station
Gainesville, Florida 32604

not belong to the genus *Pholadomya*. The family Pholadomyidae is not diverse in Recent seas (Boss, 1971), but it was particulary common in the Jurassic and to a lesser extent in the Cretaceous, gradually waning throughout the Tertiary.

Possibly *Miltha, Kuphus*, and the Clavagellidae can be considered living fossils on the basis of their past and present geographic distributions. Further careful work on the phylogenetic histories of living marine pelecypod groups will likely unearth additional relicts or living fossils.

The genus *Tellidorella* Berry, with one living species found in the Eastern Pacific, has been cited as a living fossil by Chavan (*in* Moore, ed., 1969). The genus has been allocated to the Cardiniidae by Chavan, but there is no geologic record of this family in Cretaceous or Paleogene strata. *Tellidorella* may be an example of homeomorphy, which is not a rare phenomenon amongst the pelecypods.

Some of the relict groups have changed little in the physical habitat since the Mesozoic. An example is Fimbriidae, which has always been confined to warm water. Others, for example *Astarte, Arctica*, and *Pholadomya*, lived in warm and shallow water and were widely distributed during the Jurassic and Cretaceous. *Astarte* and *Arctica* are now confined to cold and cold-temperate water and *Pholadomya* is now found in deep water. It is often fallacious to base paleoecological interpretations on present relict groups. Species of Eocene astartids do not necessarily indicate cold or cool water. In this instance the present is *not* a key to the past.

Almost every major geographic province has at least one living relict group. Five of the nine groups reviewed here have part or all of their geographic distribution in the warm water of the Western Pacific. However, the Western Pacific encompasses a large area of shallow water and has the most diverse marine pelecypod fauna in the world, and on the basis of the total pelecypod fauna, it may not have the highest percentage of relicts.

LITERATURE CITED

BOSS, K. J., 1971, Critical estimate of the number of Recent Mollusca: Harvard Mus. Comparative Zool., Occasional Papers Moll., v. 3, p. 81-135.

DAVIES, A. M., 1971, Tertiary Faunas, Volume 1: The Composition of Tertiary Faunas, 2nd ed. (Revised by F.E. Eames), American Elsevier Publishing Co., New York, 571 p.

ELDREDGE, NILES, and S. M. STANLEY (eds.), 1984, Living Fossils, Springer Verlag, New York, 291 p.

HARRY, H. W., 1986, Sententia: The relevance of the generic concept to the geographic distribution of living oysters (Gryphaeidae and Ostreidae): Amer. Malac. Bull., v. 4, p. 157-162.

MOORE, R. C. (ed.), 1969-1971, Treatise on Invertebrate Paleontology, Part N, Mollusca 6, Bivalvia (Vols. 1 and 2, 1969), Vol. 3 (1971), Univ. Kansas Press, Lawrence, p. N1-N1224.

NICOL, DAVID, 1950a, Recent species of the lucinoid pelecypod *Fimbria*: Wash. Acad. Sci., Jour., v. 40, p. 82-87.

NICOL, DAVID, 1950b, Recent species of the prionodont pelecypod *Cucullaea*: Wash. Acad. Sci., Jour., v. 40, p. 338-343.

NICOL, DAVID, 1951a, Recent species of the veneroid pelecypod *Arctica*: Wash. Acad. Sci., Jour., v. 41, p. 102-106.

NICOL, DAVID, 1951b, Recent species of the cyrenoid pelecypod *Glossus*: Wash. Acad. Sci., Jour., v. 41, p. 142-146.

NICOL, DAVID, 1981, Some observations on the hollow curve of distribution: Florida Scientist, v. 44, p. 118-123.

NICOL, DAVID, 1984, Critique on Stenzel's book on the Ostreacea: Nautilus, v. 98, p. 123-126.

THOMSON, K. S., 1987, Living Fossils (A book review): Paleobiology, v. 12, p. 495-498.

October 12, 1988

FURTHER NOTES ON *EUDOLIUM (GALEODOLIUM) SUBFASCIATUM*

J. GIBSON-SMITH and W. GIBSON-SMITH*
CARACAS, VENEZUELA

The recent publication by Vokes (1986) on the identification of a species from the Chipola Formation, of northwestern Florida, as *Eudolium (Galeodolium) subfasciatum* Sacco, 1890, prompted a reexamination of material we had previously (1979, p. 22) identified as *Semicassis (Echinophoria)* aff. *tostoma* Woodring. The latter was described by Woodring (1973, p. 476, pl. 71, figs. 9, 12-14) from internal molds, said to be "abundant in the La Boca Formation at the type locality (30 specimens)," which is the Las Cascadas reach, Canal Zone, Panama.

The internal molds figured by Woodring show a small species (maximum height ca. 28 mm) very close to *Phalium (Semicassis) aldrichi* (Dall, 1890), compared by Vokes with the specimens she referred to *Eudolium subfasciatum*. Even though there are only internal molds available, they show the recurved siphonal canal typical of *Phalium*, and one row of nodes at the shoulder.

The specimen here figured is one of seven examples from the Cantaure Formation, Paraguaná Peninsula, Venezuela, which is considered to be the same late early Miocene (Burdigalian) age as the Chipola Formation. This extension of geographic range is hardly unexpected, given the already established range extension from Italy to Florida.

Text-figure 1. *Eudolium (Galeodolium) subfasciatum* Sacco; Basel Naturhistorisches Museum no. H-17337; height 36.7 mm, diameter 28.5 mm. Locality NMB 17516, Paraguaná Peninsula, 300 m SSE of new (1952) Casa Cantaure, Venezuela.

LITERATURE CITED

GIBSON-SMITH, J. and W. GIBSON-SMITH, 1979, The genus *Arcinella* (Mollusca: Bivalvia) in Venezuela and some associated faunas: GEOS, no. 24, p. 11-32, pls. 1-3, 2 text-figures.

VOKES, E. H., 1986, Notes on the fauna of the Chipola Formation - XXX: On the presence of *Eudolium (Galeodolium) subfasciatum* Sacco (Gastropoda: Tonnidae): Tulane Stud. Geol. Paleont., v. 19, no. 4, p. 177-180, 3 text-figures.

WOODRING, W.P., 1973, Geology and Paleontology of Canal Zone and adjoining parts of Panama; description of Tertiary mollusks (additions to gastropods, scaphopods, pelecypods: Nuculidae to Malleidae): U. S. Geol. Survey, Prof. Paper 306-E, p. 453-539, pls. 67-82.

*Mailing Address:
℅ Lloyds Bank
1 The Broadway
Cheam, Surrey SM3 8BG
England

October 12, 1988

VIGNETTES OF COASTAL PLAIN GEOLOGY

JULIA ANNA GARDNER
(1882-1960)

As a graduate of Johns Hopkins University and then Assistant in Paleontology, following her degree in 1911, Julia Gardner began her lifelong study of the fossiliferous beds of the Coastal Plain. After an interruption, during World War I, when she served with the Red Cross in France, she returned to Washington, D.C. to be a Paleontologist with the U.S. Geological Survey, a position she held until her retirement in 1952. In that position she published several studies on the Tertiary molluscan faunas from Maryland to Mexico, most notably her monograph on the Alum Bluff Group of northwestern Florida. This latter opus included over 800 species, published in a single Professional Paper, the parts of which appeared in intervals over a period of 25 years. (*From* H. S. Ladd, 1962, Geological Society of America, Proceedings)

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 21, Number 4 October 12, 1988

GULF COASTAL PLAIN PITTED MILIOLACEA AND RELATED SPECIES IN GRIGNON AND DAMERY, FRANCE

HAROLD V. ANDERSEN
LOUISIANA STATE UNIVERSITY (RETIRED)
BATON ROUGE, LOUISIANA

CONTENTS

I. ABSTRACT 121
II. INTRODUCTION 122
III. DESCRIPTION OF LUTETIAN FORAMINIFERS, PARIS BASIN, FRANCE 125
IV. DESCRIPTION OF GULF COASTAL PLAIN PITTED MILIOLACEA 130
V. DISCUSSION 139
VI. ACKNOWLEDGMENTS 142
VII. REFERENCES CITED 142

ILLUSTRATIONS

FIGURES 1-10 127
FIGURES 11-16 129
FIGURES 17-24 131
FIGURES 25-32 133
FIGURES 33-41 135
FIGURE 42 137
TABLE I 124

I. ABSTRACT

Ten species of pitted Miliolacea from Grignon and Damery, France. are described and illustrated. These forms provide a model to which species from the Gulf Coastal Plain can be compared.

Twenty-four related species of foraminifera from the Gulf Coastal Plain are listed in Table I; fifteen of these are illustrated herein. The remaining nine species were described and illustrated by Andersen in 1984.

One new species, *Miliola alphillipsi*, from the type locality of the Byram Formation (Oligocene, Mississippi) is described.

The genus *Heterillina* Munier-Chalmas and Schlumberger is recognized as a form with a costate and pitted wall. The chamber arrangement is massiline and the aperture is cribrate.

Quinqueloculina stavensis Bandy, from the Yazoo Formation (Upper Eocene) at Little Stave Creek, Alabama, is regarded as a junior synonym of *Miliola saxorum* (Lamarck); *Massilina decorata* Cushman is placed in the genus *Neaguites* Andersen; and *Neaguites lamposus* (Hussey), from the Cane River Formation (Lower Eocene) in Louisiana, is considered a junior synonym of *Neaguites decoratus* (Cushman).

The concluding discussions pertaining to the pitted Miliolacea covers the following subjects: the enigmatic "knobs and doughnut-shaped elements" on the weathered wall of the test; the geological and geographical distribution of the genera;

EDITORIAL COMMITTEE FOR THIS PAPER:
HELEN TAPPAN LOEBLICH, Los Angeles, California
HUBERT C. SKINNER, Tulane University, New Orleans, Louisiana
WILLEM VAN DEN BOLD, Louisiana State University, Baton Rouge, Louisiana

the environmental implications; and, the Paris Basin species also present in the Gulf Coastal Plain.

II. INTRODUCTION

Cushman reported the presence of *Miliola saxorum* (Lamarck) in the Upper Eocene of the Gulf Coastal Plain in 1935. This, the type species of *Miliola*, originally was reported from the Lutetian of the Paris Basin, France, where many additional species of the genus occur. It is remotely possible that species other than *Miliola saxorum* or its relatives might have been overlooked.

In order to test this thesis, ten specimens of Miliolacea from Grignon and Damery, France, with structural differences at the species level were photographed with a scanning electron microscope. This established a reference model that could be used to compare the Gulf Coastal Plain species with those reported from the Paris Basin in France.

For all genera here included, the chambers of the test are pitted with pores present either within the pits and/or elsewhere in the chamber walls. In addition, the aperture is cribrate (generally delicate and seldom preserved exhibiting more than a remnant) and the wall is costate. For example, if a quinqueloculine Paleogene foraminifer has pits and costae present, it should be assigned to *Miliola* even though the cribrate aperture can not be verified.

Chamber arrangement is considered of primary importance in defining genera. But in the present study, concerned primarily with foraminifera at the species level, shape and test size are relevant. However, it is advised that test size *per se* is useful only when comparing specimens from similar environments. As hostile environments may result in reduced average size in species, the length-width ratio becomes a more important parameter. For the present study (comparing pitted Gulf Coastal Plain species with pitted European species), it is proposed that the size, shape, and distribution patterns of pits in the chamber walls and the relation of the pits to costae when present constitute the most important features to differentiate species of pitted Mioliolacea. Enlarged electron photomicrographs revealing these features are stressed in the abridged descriptions of the Mioliolacea from the Paris Basin, France.

Lutetian Samples from the Paris Basin

Participation in the American Geological Institute Paris Basin Field Trip in 1965, conducted by Maurice Lys and Samuel P. Ellison, Jr., enabled this writer to collect samples from two Lutetian localities, at Grignon and Damery, France. The type species of many genera have been described from these two famous localities where the Lutetian "calcaire grossier", a thick Eocene limestone equivalent to Middle Eocene strata in the Gulf Coastal Plain, is exposed.

Charles Pomerol prepared the geological itinerary for the Grignon and Damery portion of the Paris Basin field trip. The Grignon locality (after A. F. de Lapparent) was described in the guidebook as follows:

> "A marl quarry located in the park of the National School of Agriculture at Grignon, 200 meters to the left of the buildings. Recent exploitation has passed beyond the most fossiliferous zone which has furnished more than 1,000 species. However, we can still collect numerous shells in a remarkable state of preservation. The cut of the marl mine shows three levels. The lower level is a glauconitic sandy limestone, very fossiliferous and belonging to the Lower Lutetien (Zone III)."

The sample collected is considered to be from the base of Zone III.

The locality at Damery, France, is upper marine Lutetian. It was described in the guidebook as follows:

> "The red Cuisian sands are directly covered by sandy limestone of a part of the the Upper Lutetien (Zone III). The sandy limestone contains an abundant microfauna, particularly rich in *Milioles*."

A sample of this sandy limestone was examined for this report.

Gulf Coastal Plain Samples Neither Examined nor Re-examined

The basal Jacksonian Inglis Formation of the Ocala Group (Upper Eocene,

Florida) is the time equivalent of the Moodys Branch Formation (Upper Eocene, Mississippi). This limestone is exposed in various pits and quarries near Inglis, Levy County, Florida. In 1947, Puri recorded a tremendous invertebrate fauna from this limestone and described *Quinqueloculina ocalana* from cuttings in well 347. This species should have been placed in *Miliola* as the test surface is pitted and costate. *Miliola ocalana* (Puri) is included in Table I (Distribution of Pitted Miliolacea in the Gulf Coastal Plain).

Andersen (1984, p. 2) discussed and described sample collection localities in the Weches and Cane River formations (Claibornian, Middle Eocene) and the Moodys Branch Formation (Jacksonian, Upper Eocene). These stations were not re-examined for the present study, although the faunas from all three localities are included in Table I.

Gulf Coastal Plain Paleogene Samples Re-examined

Paleogene samples examined or re-examined for this report range from Upper Eocene through the Oligocene in age. The localities listed are in sequence from oldest to youngest (except when contemporaneous).

Crystal River Formation samples were supplied by Steve Windham, Bureau Chief, Bureau of Geology at Tallahassee, Florida. The sample studied is from the *Amusium* bed in a white chalky limestone, Locality PM-3, the Kendrick pit of the Cummer Lime and Manufacturing Company, Kendrick, Marion County, Florida (Puri, 1957, p. 2). At this outcrop, about forty feet of Crystal River Formation, Ocala Group, are exposed.

The Yazoo Formation (Upper Eocene) sample used is LSU Geoscience Museum No.-447, from Little Stave Creek (Sec. 21, T7N, R2E), Clarke County, Alabama. It was collected by Lewis Nichols from the basal clay of the Yazoo Formation, approximately five feet above the top of the Moodys Branch Formation.

The type section of the Shubuta Formation (Upper Eocene) is located in SW 1/4 Sec. 29, T10N, R5W, Wayne County, Mississippi. The sample was taken from a marl exposed along the west side of Shubuta Hill, eight to ten feet above high water level in the Chickasawhay River, east of Shubuta, Mississippi.

The Danville Landing section (Upper Eocene), consisting of two fossiliferous beds, was described by Veatch (1902, p. 167). Danville Landing is on the Ouachita River in Catahoula Parish, Louisiana, just south of the Caldwell-Catahoula parish line. The upper bed in this section, studied from samples available at LSU in the 1950's, was much more fossiliferous than the lower bed. This upper bed, consisting of light yellow fossiliferous clay, was lost to bank erosion by the Ouachita River fifty or more years ago.

The Red Bluff Formation (Oligocene) samples came from two localities. Most of the specimens studied here are from samples collected in the 1950's and 1960's from an outcrop located between the Hiwannee Railroad station and the Chickasawhay River. Today, the railroad station has been moved and the outcrop is covered and inaccessible. The second sample, Geology Museum Locality (GML) 447, is from the west bank of the Chickasawhay River in SW 1/4 Sec 28, T7N, R10W, Wayne County, Mississippi. This is close to the type locality of the Red Bluff Formation and in 1948, when the sample was collected, the section was considered better than the type section of the Red Bluff. The sample studied is from the glauconite ledge just above the disconformity separating the Red Bluff from the Upper Jackson.

The Rosefield Formation (Oligocene) sample is from Shell Branch, 2 1/2 miles south of Rosefield, Catahoula Parish, Louisiana.

The Glendon Formation (Oligocene) sample is from the type locality of the Byram Formation. The sample studied, a gray silty clay, is exposed beneath the indurated ledge at the base of the Byram Formation at extreme low water level in the Pearl River.

The Mint Springs Marl (Oligocene) material, GML 131A - sample 1, was collected beneath a waterfall on Glass Bayou located across the street from a residence at 611 North Cherry Street, within the city of Vicksburg, Mississippi.

Most of the pitted Miliolacea figured in this report came from the type locality of

TABLE 1

Distribution of Pitted Miliolacea in the Gulf Coastal Plain

GULF COASTAL PLAIN SPECIES	EOCENE								OLIGOCENE						M
	Weches Formation	Cane River Fm.	Inglis Formation	Moodys Branch Fm.	Crystal River Fm.	Yazoo Formation	Shubuta Formation	Danville Landing	Chickasawhay Marl	Mint Springs Fm.	Rosefield Fm.	Red Bluff Fm.	Glendon Formation	Byram Formation	Chipola Formation
Miliola chipolensis (Cushman & Ponton)															○
" byramensis (Cushman)												○		●	○
" cf. M. chipolensis														○	
" rolandi Andersen												●			
" alphillipsi, new species														○	
" cf. M. saxorum					○							○			
" sp. A														○	
" sp. B														○	
" sp. C									○						
" cf. M. jacksonensis						○									
Quinqueloculina tessellata Cushman										○				○	
Picouina mississippiensis (Cushman)														●	
Neaguites byramensis (Cushman)														●	
" inusitatus Andersen												●			
" imprimatus (Cushman)														●	
" sp. A												○		○	
" decoratus (Cushman)*		●				○	○	○	○	○	○	○	○	○	
Miliola newberryensis (Puri)					○										
" saxorum (Lamarck)				●											
" jacksonensis (Cushman)				●											
" ocalana (Puri)			○												
Heterillina jacksonensis (Cushman)				●		?									
" punctatocostata (Cushman)				●											
Texina ferayi Andersen	●														

● Described and illustrated in Tulane Stud. Geol. Paleont., vol. 18, no. 1, October 31, 1984.

* Described as Neaguites lamposus (Hussey) by Andersen in 1984.

the Byram Formation, just north of the bridge on the Pearl River, east of Byram, Mississippi. Low water exposes an indurated ledge which may represent an unconformity between the Byram and the underlying Glendon Formation. The sample studied is from the glauconitic marl above the indurated ledge. It was very carefully washed by decantation to prevent destruction of the fragile tests of the pitted Miliolacea recovered from this sample.

The Chickasawhay Marl (Oligocene) sample studied is from one of the fossiliferous clays in an exposure on State Highway 29, 1.4 miles north of Millry, Washington County, Alabama.

Gulf Coastal Plain Neogene Samples Examined

The only Neogene material included in this report is from the Chipola Formation (Miocene) in peninsular Florida. The material studied, GML 852, is from an outcrop of the Chipola Formation (Alum Bluff Group) on Ten Mile Creek near Baileys Ferry on the Chipola River, Calhoun County, Florida.

Repository for Figured Specimens

All of the figured specimens are deposited in the Geoscience Museum collections at Louisiana State University (LSU GM).

III. DESCRIPTION OF LUTETIAN FORAMINFERS, PARIS BASIN, FRANCE

Family MILIOLIDAE Ehrenberg, 1839
Subfamily MILIOLINAE Ehrenberg, 1839

MILIOLA SAXORUM (Lamarck)
Figures 1-3

Miliolites saxorum LAMARCK, 1804, Ann. Mus. Hist. Nat., vol. 5, p. 352.

Quinqueloculina saxorum (Lamarck). D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 301, pl. 16, figs. 10-14; TERQUEM, 1882, Mem. Soc. Geol. France, ser. 3, vol. 2, p. 181, pl. 19, fig. 22.

Miliola saxorum (Lamarck). CUSHMAN, 1935, U. S. Geol. Surv., Prof. Paper 181, p. 12, 13, pl. 3, figs. 1-3; Y. LE CALVEZ, 1947, Mem. Expl. Carte Geol. France, pt. 1, p. 30; KAASSCHIETER, 1961, Inst. Royal Sci. Nat. Belgique, Mem. 147, p. 161, pl. 4, figs. 25-27, pl. 5, fig. 1; Y. LE CALVEZ, 1970, Centre Natl. Rech. Sci., Paris, p. 43, pl. 6, fig. 3.

Abridged Description: Quinqueloculine chamber arrangement; length slightly over two and one-half times width; periphery rounded; no costae; enlarged electron photomicrograph shows irregularly shaped pits aligned with the long axis of the test, distributed at about the diameter of one pit apart; pores visible in pits not filled with debris; aperture cribrate. Length of specimen No. 10,511 from Grignon (Figure 1), 1.5 mm; width 0.60 mm.

Remarks: An electron photomicrograph of the fractured and weathered wall on a specimen of *Miliola saxorum* from Damery shows the surface layer of the test wall overlying a mass of rodlike structures (crystals, enlarged in Figure 3), and two weathered pits. The orientation of crystals in the outer layer of the test (see left side, Figure 2) is not revealed; however, an electron photomicrograph of "*Quinqueloculina*" *tuberculata* (not figured) shows that it consists of a single layer of interlocked, elongate, flat crystals, aligned parallel to the contours of the test; the second or middle layer consists of a thick mass of short, rodlike crystals randomly oriented; and, the third or inner layer, possibly exposed at the base of the pits, appears to be similar to the surface layer. This three-layered test wall is believed to be characteristic of all members of the pitted Miliolacea lineage.

MILIOLA TERQUEMI Andersen, n. sp.
Figures, 4, 5

Miliola prisca (d'Orbigny) var. *terquemi* KAASSCHIETER, 1961, Inst. Royal Sci. Nat. Belgique, Mem. 147, p. 164, pl. 5, fig. 7a-c.

Abridged Description: Quinqueloculine chamber arrangement; length about one and one-half times width; chambers carinate; generally smooth except for one specimen (see No. 10,514, Figure 5) with a single costa on the chamber wall; enlarged wall of test shows that the pits are small, elliptical in outline and randomly distributed over the surface of the test, spaced about one-half to one pit diameter apart; pores not discernible in pits; aperture cribrate. Length of holotype (specimen No. 10,513), from Grignon, 0.63 mm; width 0.43 mm.

Remarks: After 1960, varieties have no standing in zoological nomenclature (see ICZN art. 16). Thus, the name designated

by Kaasschieter for his "variety" is invalid as proposed. The species-group taxon *terquemi* is validated herein, is elevated to the species level, and is recognized as distinct from *Miliola prisca* (d'Orbigny).

MILIOLA cf. M. BIROSTRIS (Lamarck)
Figure 6

Miliolites birostris LAMARCK, 1804, Ann. Mus., Hist. Nat., vol. 5, p. 353.

Quinqueloculina birostris (Lamarck). TERQUEM, 1882, Mem. Soc. Geol. France, ser. 3, vol. 2, p. 181, pl. 19, fig. 23; Y. DE CALVEZ, 1947, Mem. Expl. Carte Geol. France, pt. 1, p. 8, pl. 1, figs. 4-6.

Miliola birostris (Lamarck). Y. LE CALVEZ, 1952, Mem. Expl. Carte del France, pt. 4, pl. 46; KAASSCHIETER, 1961, Inst. Royal Sci. Nat. Belgique, Mem. 147, p. 162, pl. 5, fig. 2.

Abridged Description: Quinqueloculine chamber arrangement; length about four times width; periphery rounded except at distal end of test, which is carinate; costate near proximal end of final chamber; enlarged surface of test wall shows that the pits are round, closely spaced, and longitudinally aligned; pores present in pits; aperture poorly preserved, probably cribrate. Length of specimen No. 10,515 from Grignon (Figure 6), 1.16 mm; width 0.30 mm.

MILIOLA sp. 1
Figure 7

Description: Quinqueloculine chamber arrangement; length about one and two-thirds times width; periphery rounded; costate; enlarged electron photomicrograph shows the surface of the test with transverse bridges between longitudinal costae compartmentalizing the single rows of elliptically shaped pits; pores not visible in pits; aperture cribrate. Length of specimen No. 10,516 from Grignon (Figure 7), 0.80 mm; width 0.50 mm.

Remarks: This specimen has the test shape of *Miliola prisca* (d'Orbigny) as illustrated by Kaasschieter (1961, pl. 5, fig. 4) and the striae described by Kaasschieter for *M. prisca strigilla* (d'Orbigny) (1961, pl. 5, fig. 6). However, his illustration of the subspecies is nearly as wide as long, which differs from *Miliola* sp. 1.

MILIOLA sp. 2
Figure 8

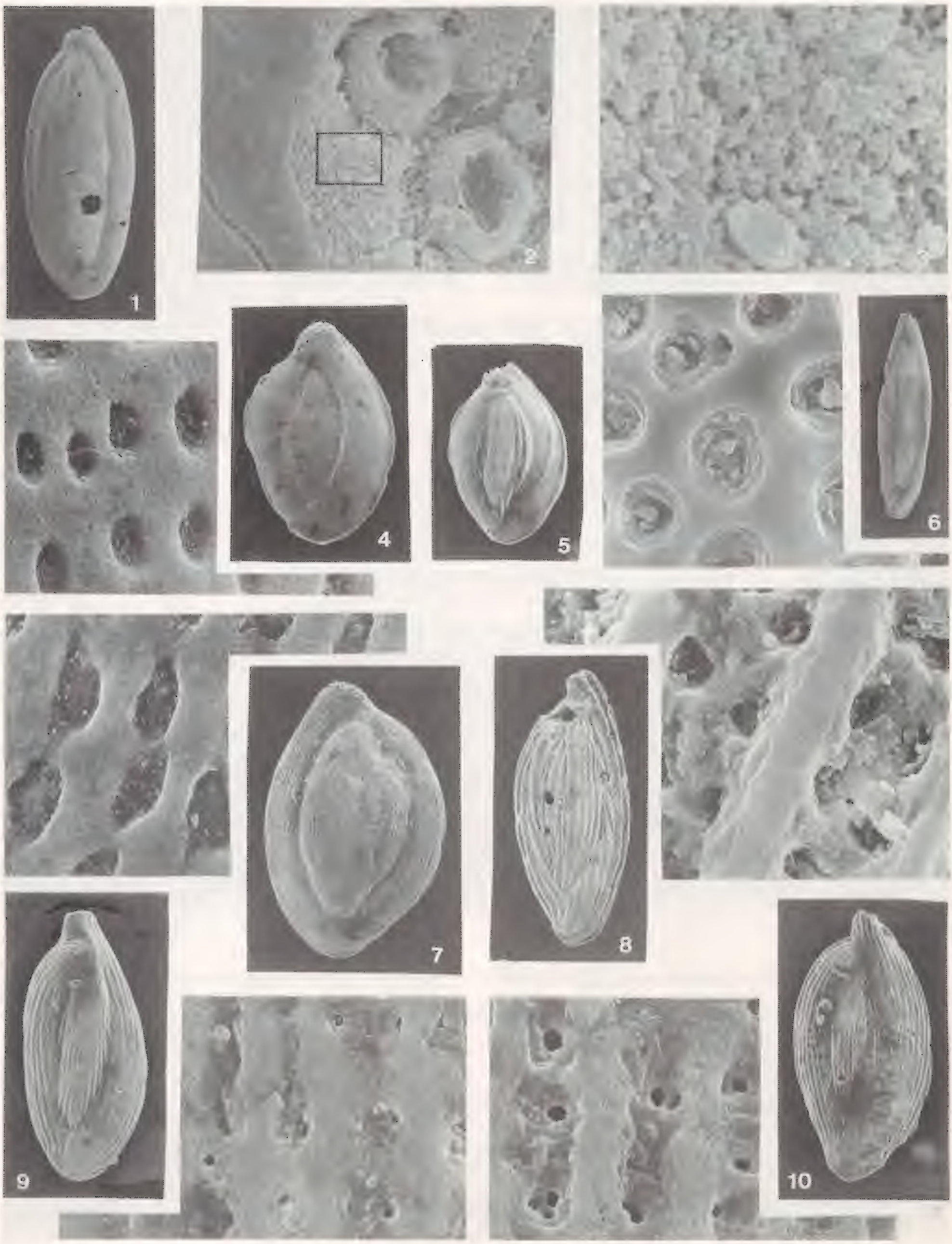
Description: Quinqueloculine chamber arrangement; length a little more than twice width; periphery rounded; costae thin and slightly elevated above test surface; enlarged electron photomicrograph shows pits arranged

---

FIGURES

1-3. *Miliola saxorum* (Lamarck)
   1. Lateral view, X 25 (LSU GM No. 10511)
   2. Layering within wall and weathered pits, X 1000 (LSU GM No. 10,512)
   3. Orientation of crystals within middle layer of wall, X 5000 (LSU GM No. 10,512)

4. *Miliola terquemi* Andersen, n. sp. (LSU GM No. 10,513)
   Lateral view, X 50
   Enlargement of pits, X 1000
5. *Miliola terquemi* Andersen, n. sp. (LSU GM No. 10,514)
   Lateral view, X 50
6. *Miliola* cf. *M. birostris* (Lamarck). (LSU GM No. 10,515)
   Lateral view, X 25
   Enlargement of pits, X 1000
7. *Miliola* sp. 1. (LSU GM No. 10,516)
   Lateral view, X 50
   Enlargement of pits, X 1000
8. *Miliola* sp. 2. (LSU GM No. 10,517)
   Lateral view, X 50
   Enlargement of pits, X 1000
9. *Miliola* sp. 3. (LSU GM No. 10,518)
   Lateral view, X 50
   Enlargement of pits, X 1000
10. *Miliola* sp. 3 ?. (LSU GM No. 10,519)
   Lateral view, X 50
   Enlargement of pits, X 1000



FIGURES 1-10

two abreast in longitudinal rows between costae; pores present in pits; aperture poorly preserved, probably cribrate. Length of specimen No. 10,517 from Grignon (Figure 8), 0.80 mm; width 0.35 mm.

MILIOLA sp. 3
Figures 9, 10

Description: Quinqueloculine chamber arrangement; length more than twice width; periphery rounded; costate; pores present in some pits; enlarged electron photomicrograph shows a single row of pits between costae with spacing not determinable due to weathering; aperture elevated on a neck extending above penultimate chansiline chamber arrangement and the pit distribution pattern (more clearly defined) is the same. Length of specimen No. 10,519, 0.76 mm; width 0.38 mm.

PICOUINA sp.
Figure 11

Description: Triloculine chamber arrangement; length about one and one third times width; periphery broadly angular; surface smooth; enlarged electron photomicrograph shows that the pits are elongated elliptical depressions aligned longitudinally; pores not apparent in pits; aperture cribrate. Length of specimen No. 10,520 from Grignon (Figure 11), 0.83 mm; width 0.58 mm.

HETERILLINA sp. 1
Figure 12

Description: Massiline chamber arrangement; length about one and two-thirds width; sides of test flattened; periphery rounded; costate; enlarged electro photomicrograph shows single row of pits between costae; pores present in pits; aperture flush with base of penultimate chamber; aperture poorly preserved, indeterminate. Length of specimen No. 10,521 from Damery (Figure 12), 0.90 mm; width 0.55 mm.

Remarks: This species differs from the abnormal specimen of *Miliola* sp. 3 in having an aperture flush with the base of the penultimate chamber and in the absence of transverse bridges connecting adjacent costae.

HETERILLINA sp. 2
Figure 13

Description: Massiline chamber arrangement; length slightly greater than width; test with flattened sides; periphery acute; not costate; enlarged electron photomicrograph shows that the pits are small, spaced about the diameter of one pit apart and aligned longitudinally; pores present in pits; aperture broken, but appears cribrate. Length of specimen No. 10,522 from Damery (Figure 13), 0.45 mm; width 0.38 mm.

NEAGUITES PERTUSUS (Terquem)
Figures 14-16

Spiroloculina pertusa TERQUEM, 1882, Mem. Soc. Geol. France, ser. 3, vol. 2, p. 160, pl. 16, figs. 27a, b.

Abridged Description: Spiroloculine chamber arrangement; length twice the width; sides of test flattened; periphery truncated; not costate; enlarged electron photomicrograph shows three rows of pits on the final chamber, parallel to the curvature of the test; pores in pits (see Figure 15); aperture with tooth (see Figure 16). Length of specimen No. 10,523 from Grignon (Figure 15), 0.63 mm; width 0.30 mm.

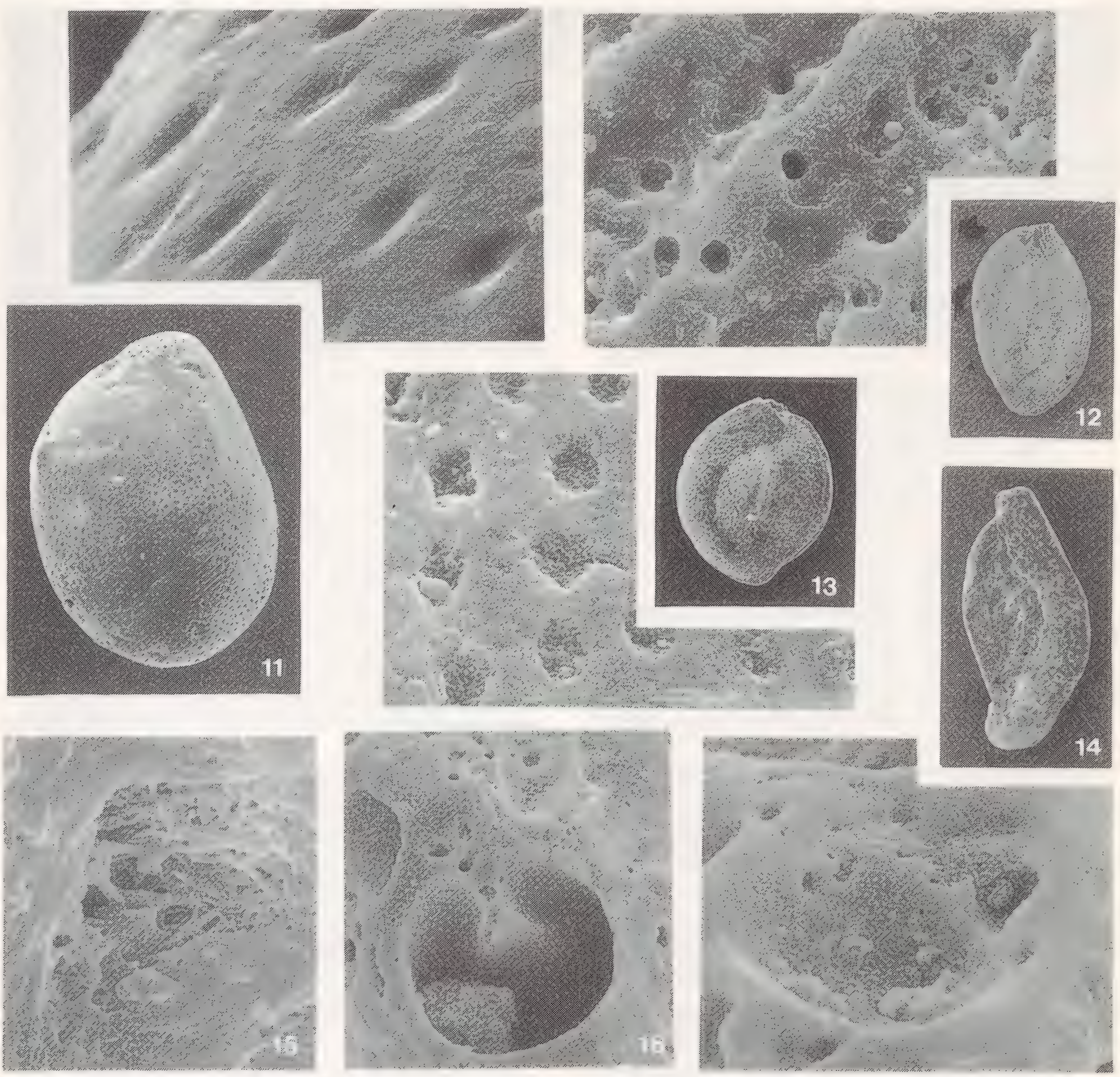
Remarks: The enlarged electron photomicrograph of a pit on *Neaguites pertusus* (Terquem) (see Figure 14) shows a single

---

FIGURES

11. *Picouina* sp. (LSU GM No. 10,520)
    Lateral view, X 50
    Enlargement of pits, X 1000
12. *Heterillina* sp. 1. (LSU GM No. 10,521)
    Lateral view, X 25
    Enlargement of pits, X 1000
13. *Heterillina* sp. 2. (LSU GM No. 10,522)
    Lateral view, X 50
    Enlargement of pits, X 1000

14-16. *Neaguites pertusus* (Terquem). (LSU GM No. 10,523)
    14. Lateral view, X 50
        Enlargement of pits, X 1000
    15. Enlargement of pit showing crystals in middle layer of wall X 3750
    16. Apertural view showing tooth ?, X 500 (LSU GM No. 10,545)



FIGURES 11-16

"doughnut-shaped" element within the pit. Such features occur also on *Neaguites decoratus* (Cushman) (see figures 35, 37, and 38). This writer considers these elements to originate through weathering of the wall structure around the pores (see discussion in part V, this report).

IV. DESCRIPTION OF GULF COASTAL PLAIN PITTED MILIOLACEA

Family MILIOLIDAE Ehrenberg, 1839

Subfamily MILIOLINAE Ehrenberg, 1839

MILIOLA SAXORUM (Lamarck)
Figures 17, 18

Miliolites saxorum LAMARCK, 1804, Ann. Mus. Nat. Hist., vol. 5, p. 352.

Quinqueloculina saxorum (Lamarck). D'ORBIGNY, 1826, Ann. Sci. Nat., vol. 7, p. 301, no. 1, pl. 16, figs. 10-14.

Miliola saxorum (Lamarck). CUSHMAN, 1935, U. S. Geol. Surv., Prof. Paper 181, p. 12, 13, pl. 3, figs. 1-3; BERGQUIST, 1942, Mississippi Geol. Surv., Bull. 49, p. 25, pl. 2, fig. 8; CUSHMAN and TODD, 1945, Cushman Contr. Foram. Res., Contr., vol. 21, pt. 4, p. 83; ANDERSEN, 1984, Tulane Stud. Geol. Paleont., vol. 18, no. 1, p. 5, figs. 5-16.

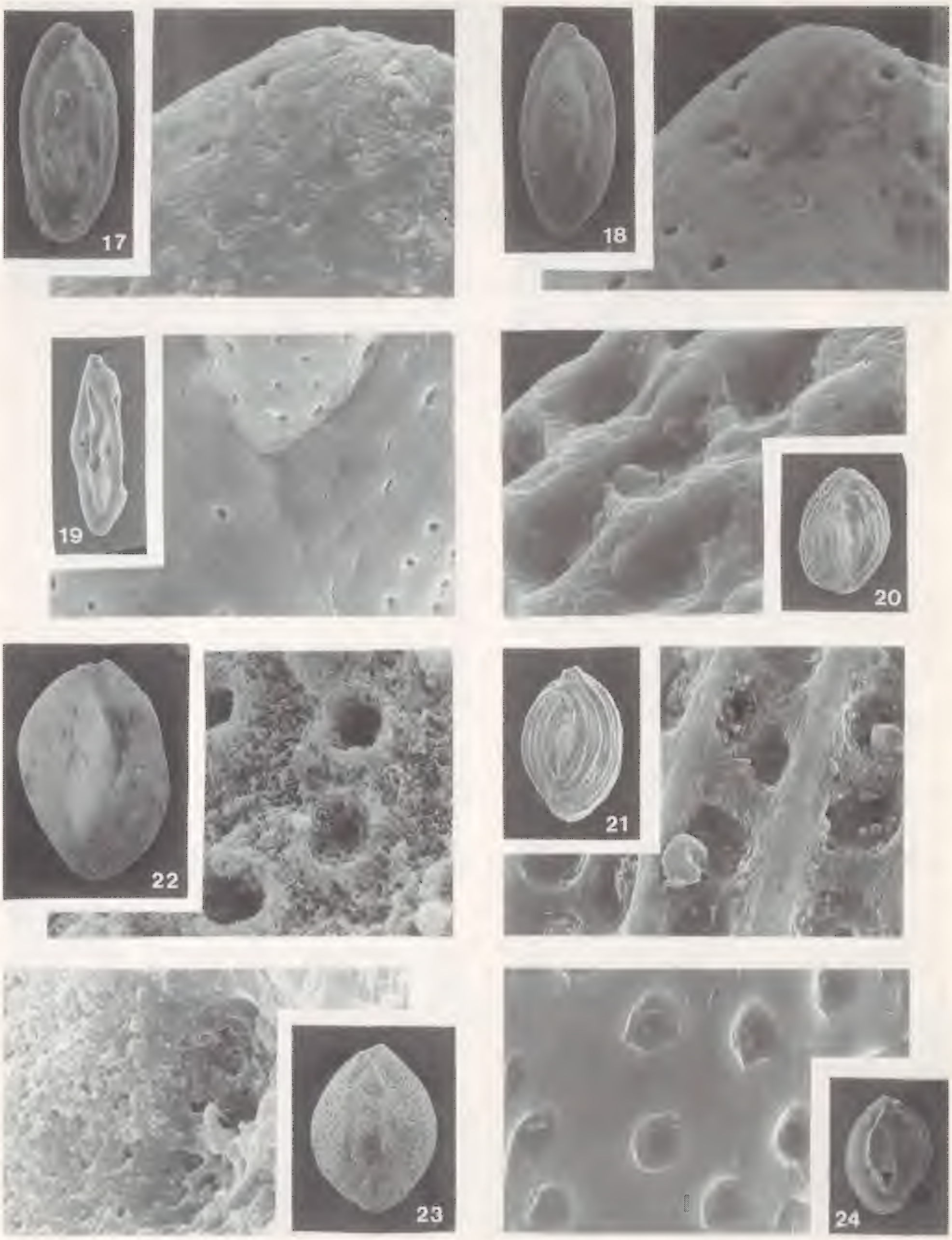
Quinqueloculina stavensis BANDY, 1949, Bulls. Amer. Paleontology, vol. 32, no. 131, p. 21, pl. 2, figs. 2a-c.

Remarks: Specimen No. 10,524 (Figure 17) was recovered from a sample collected by Lewis Nichols for the LSU Geology Department Museum, which duplicated as nearly as possible Bandy's Station 46, the basal clay in the Yazoo Formation. All of the foraminiferal tests recovered from this sample were replaced by silica, which obscured the structure of the wall. The diagenetic changes to which these Miliolacea were subjected left little more than test outlines upon which to base the identification of the species present.

Specimen No. 10,525 (Figure 18) from the Moodys Branch Formation at Riverside Park, Jackson, Mississippi, identified as *Miliola saxorum*, when compared to a topotype specimen (Figure 17) of *Quinqueloculina stavensis* Bandy, shows that the two specimens have identical shapes and identical distributions of pits near the apertures on both specimens. The conclusion reached is that Bandy's species is a junior synonym of *Miliola saxorum* (Lamarck). Length of specimen No. 10,524

FIGURES

17. *Miliola saxorum* (Lamarck). (LSU GM No. 10,524)
    Lateral view, X 25
    Enlargement of pits, X 1000
18. *Miliola saxorum* (Lamarck). (LSU GM No. 10,525)
    Lateral view, X 25
    Enlargement of pits, X 1000
19. *Miliola* cf. *M. saxorum* (Lamarck). (LSU GM No. 10,526)
    Lateral view, X 50
    Enlargement of pits, X 1000
20. *Miliola byramensis* (Cushman). (LSU GM No. 10,527)
    Lateral view, X 50
    Enlargement of pits, X 1000
21. *Miliola byramensis* (Cushman). (LSU GM No. 10,528)
    Lateral view, X 50
    Enlargement of pits, X 1000
22. *Miliola chipolensis* (Cushman and Ponton). (LSU GM No. 10,529)
    Lateral view, X 25
    Enlargement of pits, X 1000
23. *Miliola chipolensis* (Cushman and Ponton). (LSU GM No. 10,530)
    Lateral view of juvenile, X 50
    Enlargement of a pit showing crystals in middle layer of wall, X 3750
24. *Miliola* cf. *M. chipolensis* (Cushman and Ponton). (LSU GM No. 10,531)
    Lateral view, X 50
    Enlargement of pits, X 1000



FIGURES 17-24

from the Yazoo Formation (Figure 17), 1.26 mm; width 0.58 mm. Length of specimen No. 10,525 from the Moodys Branch Formation (Figure 18), 1.22 mm; width 0.56 mm.

MILIOLA cf. M. SAXORUM (Lamarck)
Figure 19

Description: Quinqueloculine chamber arrangement; length three times width; periphery rounded; surface of test smooth; pits extremely small, somewhat irregularly aligned with the long axis of the test; aperture poorly preserved, probably cribrate. Length of specimen No. 10,526 from the Red Bluff Formation, 1.02 mm; width 0.34 mm.

Remarks: The length-width ratio of this specimen does not fall within the normal range for *Miliola saxorum*, but in other respects it is similar.

MILIOLA BYRAMENSIS (Cushman)
Figures 20, 21

Quinqueloculina byramensis CUSHMAN, 1923, U. S. Geol. Surv. Prof. Paper 133, p. 54, pl. 8, fig. 3.

Miliola byramensis (Cushman). ANDERSEN, 1984, Tulane Stud. Geol. Paleont., vol. 18, no. 1, p. 8, figs. 20-22.

Remarks: Specimen No. 10,527, from the Chipola Formation (Figure 20), is most typical of the species. Specimen No. 10,528 from the Red Bluff Formation (Figure 21), is less rugose but within an acceptable range of variation.

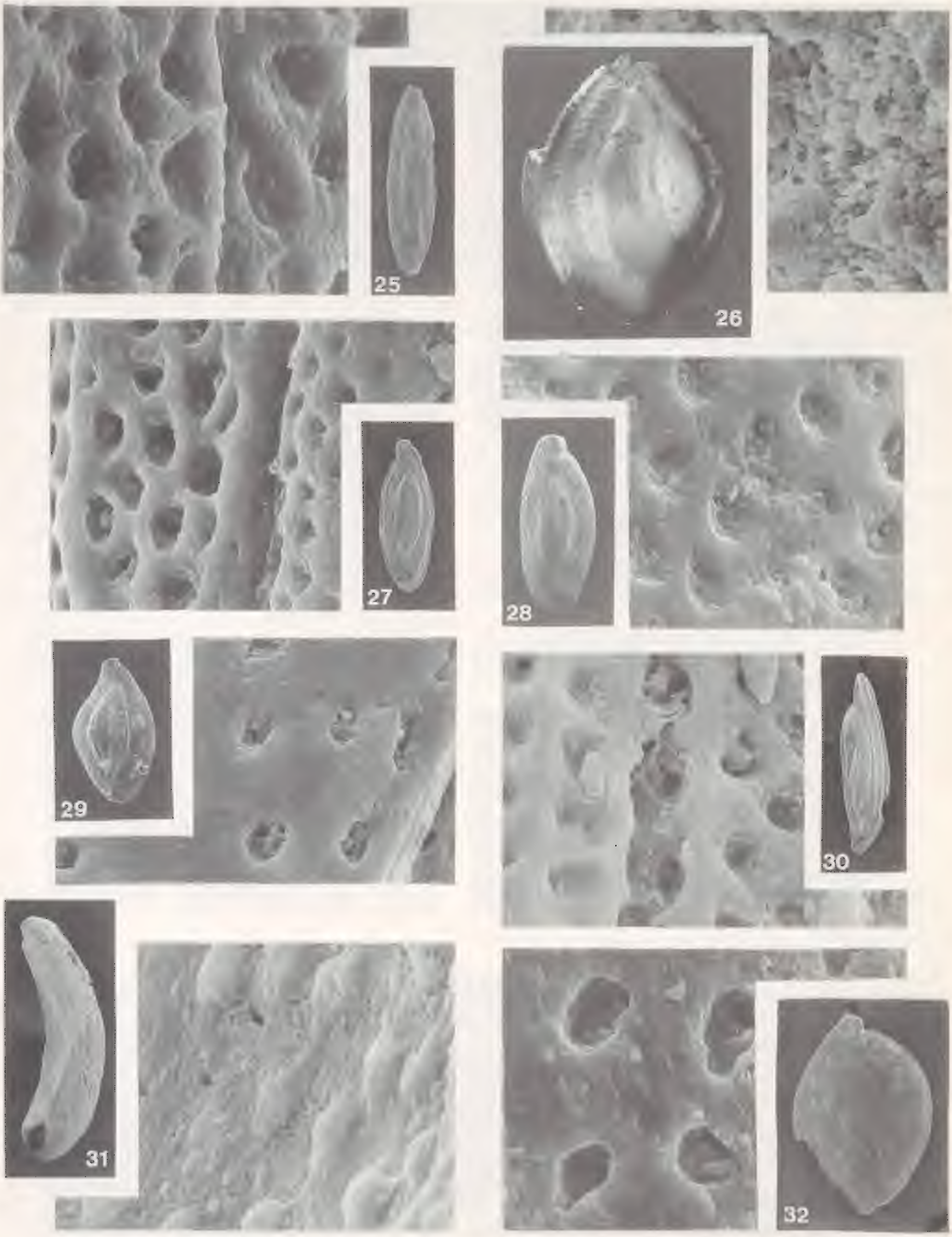
MILIOLA CHIPOLENSIS (Cushman and Ponton)
Figures 22, 23

Quinqueloculina chipolensis CUSHMAN and PONTON, 1932, Florida Geol. Surv., Bull. 9, p. 45, pl. 3, figs. 1-3.

Abridged Description: Quinqueloculine chamber arrangement; length ranges from one and one-third times width in young specimens to one and one-half times width in the adult; periphery acutely angular, almost forming a keel in some specimens; test wall smooth; pits randomly distributed over test wall, spaced about one pit diameter apart; pores present in pits; crystals of calcite randomly oriented in the middle layer of the test wall (see Figure 23); aperture poorly preserved, probably cribrate. Length of specimen No. 10,529 from the Chipola Formation (Figure 22, an adult test), 1.22 mm; width 0.84mm. Length of specimen No. 10,530 also from the Chipola Formation (Figure 23, a juvenile test), 0.48 mm; width 0.35 mm.

FIGURES

25. *Miliola* cf. *M. jacksonensis* Cushman. (LSU GM No. 10,532)
    Lateral view, X 25
    Enlargement of pits, X 1000
26. *Miliola newberryensis* (Puri). (LSU GM No. 10,533)
    Lateral view, X 50
    Enlargement of pits, X 1000
27. *Miliola rolandi* Andersen. (LSU GM No. 10,534)
    Lateral view, X 50
    Enlargement of pits, X 1000
28. *Miliola alphillipsi* Andersen, n. sp. (LSU GM No. 10,535)
    Lateral view, X 50
    Enlargement of pits, X 1000
29. *Miliola* sp. A. (LSU GM No. 10,536)
    Lateral view, X 50
    Enlargement of pits, X 1000
30. *Miliola* sp. B. (LSU GM No. 10,537)
    Lateral view, X 50
    Enlargement of pits, X 1000
31. *Miliola* sp. C. (LSU GM No. 10,538)
    Lateral view, X 50
    Enlargement of pits, X 1000
32. *Heterillina jacksonensis* (Cushman). (LSU GM No. 10,540)
    Lateral view, X 25
    Enlargement of pits, X 1000



FIGURES 25-32

Remarks: None of the specimens recovered from the Chipola Formation samples exhibited a tooth as figured by Cushman and Ponton (1932, pl. 3, fig. 1) in their original definition of this species.

MILIOLA cf. M. CHIPOLENSIS
(Cushman and Ponton)
Figure 24

Remarks: The length of specimen No. 10,531 from the Red Bluff Formation (Figure 24) is 0.35 mm; the width is 0.24 mm. The length-width ratio of this specimen is similar to that for topotype specimen No. 10,529 from the Chipola samples (Figure 22), but the test is smaller. As it is the largest specimen recovered from the Red Bluff samples, it is regarded as an adult.

Although the surface, the distribution of pits on the test wall, and the absence of a tooth conform to identification of this form as *M. chipolensis*, absolute assignment to this species is withheld because of its smaller size.

MILIOLA cf. M. JACKSONENSIS Cushman
Figure 25

Remarks: This species was reported by Bandy (1949) from Station 46, a clay at the base of the Yazoo Formation in Little Stave Creek, Alabama. Bandy described the wall as siliceous because the wall of the test had been replaced with silica.

The length of specimen No. 10,532 (Figure 25) is 1.06 mm; the width is 0.28 mm. Its length-width ratio is close to that of topotypes of *Miliola jacksonensis* from the Moodys Branch Formation in Jackson, Mississipppi, but it does not have the costae extending well above the surface of the test wall nor the network of pores illustrated by Andersen in 1984 (fig. 19). This specimen is too large to be assigned to *Miliola rolandi* Andersen.

MILIOLA NEWBERRYENSIS (Puri)
Figure 26

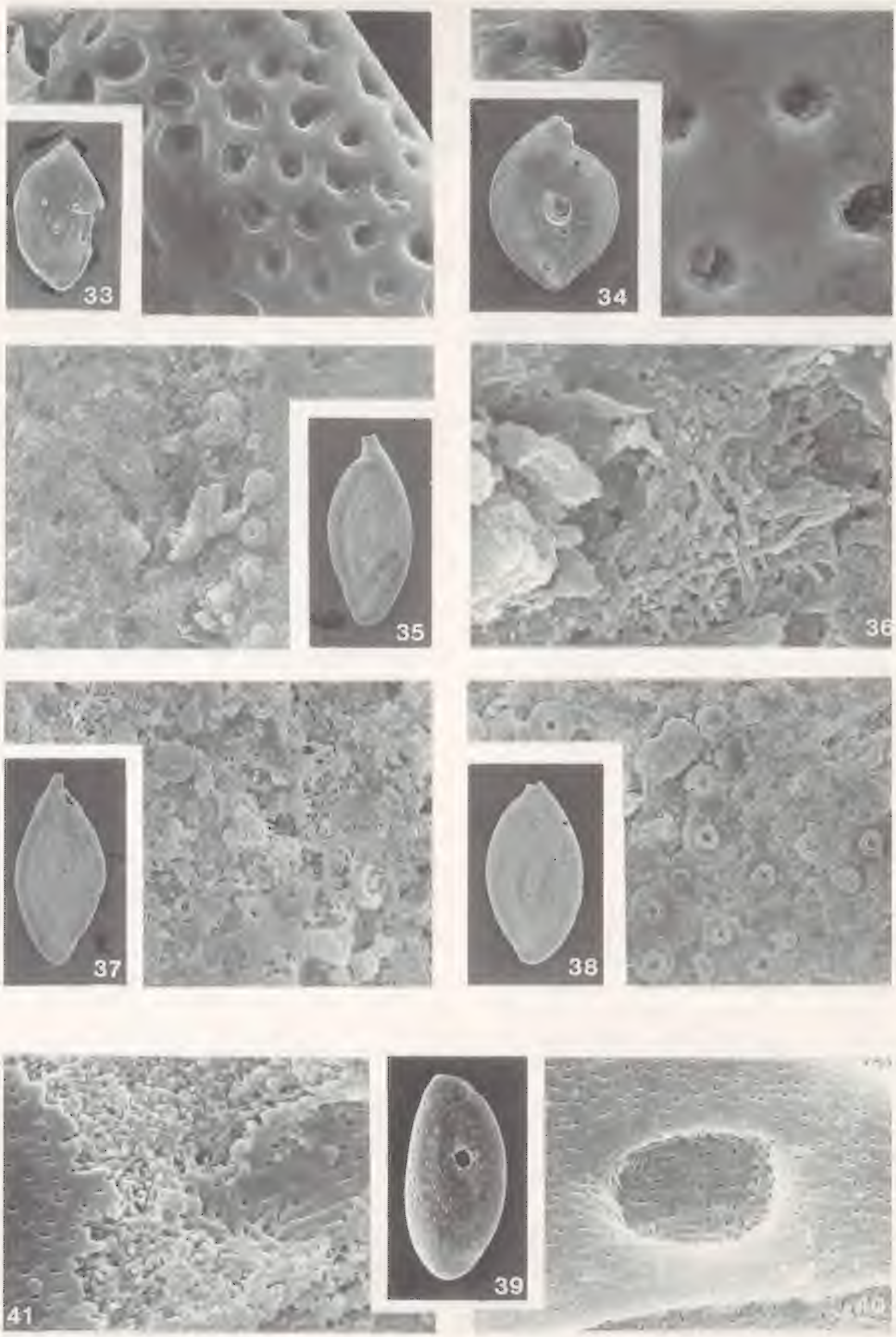
Quinqueloculina newberryensis PURI, 1957, Florida Geol. Surv., Bull. 38, p. 107, pl. 3, figs. 3a, b.

Remarks: This is the most robust species of *Miliola* reported from the Gulf Coastal Plain and the figured specimen is the best recovered from the sample examined. Unfortunately, a detailed study could not be made of its weathered surface and the specimen was so badly damaged by the scanning electron microscope that it could

---

FIGURES

33. *Neaguites byramensis* (Cushman). (LSU GM No. 10,539)
    Lateral view, X 50
    Enlargement of pits, X 1000
34. *Neaguites* sp. A. (LSU GM No. 10,541)
    Lateral view, X 50
    Enlargement of pits, X 1000
35-36. *Neaguites decoratus* (Cushman). (LSU GM No. 10,542)
    35. Lateral view with proloculus concealed, X 50
        Enlargement of wall showing doughnut-shaped structures formed around perforations, X 3750
    36. Enlargement of a pit showing crystals in middle layer of test wall, X 3750
37. *Neaguites decoratus* (Cushman). (LSU GM No. 10,543)
    Lateral view with proloculus showing, X 50
    Enlargement of wall showing doughnut-shaped structures formed around perforations X 1000
38. *Neaguites decoratus* (Cushman). (LSU GM No. 10,544)
    Lateral view with proloculus concealed, X 50
    Enlargement of wall showing doughnut-shaped structures formed around perforations, X 1000
39-41. *Quinqueloculina semireticulosa* Cushman.
    39. Lateral view, X 75
    40. Enlargement of a pit, X 2500
    41. Section of wall showing layering, X 3750



FIGURES 33-41

not be saved.

Length of specimen No. 10,533 from the Crystal River Formation (Figure 26), 0.72 mm; width 0.60 mm.

MILIOLA OCALANA (Puri)

Quinqueloculina ocalana PURI, 1957, Florida Geol. Surv., Bull. 38, p. 107, pl. 3, figs. 3a, b.

Remarks: This costate and pitted species, with an average length of 1.5 mm, is common in the Ingles Formation (Lower Jackson Group of Florida), according to Puri (1957, p. 24). No samples or specimens of this species were available for this investigation.

MILIOLA ROLANDI Andersen
Figure 27

Miliola rolandi ANDERSEN, 1984, Tulane Stud. Geol. Paleont., vol. 18, no. 1, p. 8, figs. 24, 25.

Remarks: The holotype of *Miliola rolandi*, incorrectly reported by Andersen (1984) to be from the Moodys Branch Formation, is from the Red Bluff Formation, the same locality as specimen No. 10,534 (Figure 27), length 0.42 mm; width 0.15 mm.

MILIOLA ALPHILLIPSI, n. sp.
Figure 28

Description: Quinqueloculine chamber arrangement; slightly more than twice as long as wide; transverse section of test broadly triangular with periphery rounded; neck extending above penultimate chamber; surface covered with closely spaced pits randomly distributed at distal end of final chamber, aligned between costae that are parallel to long axis of test near aperture; pores present in each pit; aperture without tooth, probably cribrate but incomplete. Length of holotype, specimen No. 10,535 from the type locality of the Byram Formation (Figure 28), 0.49 mm; width 0.21 mm.

Remarks: The figured specimen is considered an adult as no other in the sample was appreciably larger. It is the most abundant pitted species.

This species is named for Alvin Phillips, Curator of Foraminifera, School of Geoscience Museum, Louisiana State University, whose assistance in the preparation of this paper is greatly appreciated.

MILIOLA sp. A
Figure 29

Remarks: This quinqueloculine specimen differs from *Miliola chipolensis* in the less carinate periphery, smaller and more closely spaced pits, and in the presence of an apertural neck.

Length of specimen No. 10,536 from the Byram Formation (Figure 29), 0.41 mm; width 0.23 mm.

MILIOLA sp. B
Figure 30

Remarks: This specimen is one of several examples of Miliolacea with the length-width ratio about 4:1 recovered from samples collected in the Paris Basin and in the Gulf Coastal Plain. Its shape is similar to *Miliola jacksonensis* but an electron photomicrograph of the wall shows that it lacks the lace-like network of pores that is present in that species.

Length of specimen No. 10,537 from the Byram Formation (Figure 30), 0.50 mm; width 0.14 mm.

MILIOLA sp. C
Figure 31

Remarks: The specimens of *Miliola* recovered from the Chickasawhay Marl near Millry, Alabama, consist of single chambers with casts of pits on the outer surface of the chamber floor. These casts are aligned with the long axis of the chamber and appear elliptical in outline. This pattern has not been observed on any other species from the Gulf Coastal Plain, but is present on *Miliola* sp. 1 from the Paris Basin.

Length of specimen No. 10,538 (Figure 31), 0.79 mm.

"QUINQUELOCULINA" TESSELLATA Cushman

Quinquloculia tessellata CUSHMAN, 1922, U. S. Geol. Surv. Prof. Paper 129-F, p. 142, pl. 33, fig. 8 and pl. 34, fig. 1; CUSHMAN, 1923, U. S. Geol. Surv. Prof. Paper 133, p. 54, not figured; CUSHMAN and McGLAMERY, 1942, U. S. Geol. Surv., Prof. Paper 197-B, p. 66, pl. 4, fig. 1; BERGQUIST, 1942, Mississippi Geol. Surv., Bull. 49, pl. 2, figs. 11, 14; TODD, 1952, U. S. Geol. Surv., Prof. Paper 241, p. 7, not figured.

Remarks: Quinqueloculina tessellata Cushman, reported originally from the Glass Bayou and Mint Springs Bayou calcareous marls exposed in Vicksburg, Mississippi, was described as follows:

> "Test elongate, fusiform, in transverse section much angled; periphery rather sharply angled, sides flat and slightly convex, apertural end very little extended; sutures not very distinct; surface ornamented by longitudinal rows of rather large pits, five or six rows on each side of the largest chamber. Length 1.25 millimeters, breadth 0.5 millimeter."

Of the two figures illustrated, figure 8 was designated the type specimen.

Cushman's statement that the test of "*Quinqueloculina*" *tessellata* was "ornamented by longitudinal rows of rather large pits" is adequate evidence that his species belongs to the *Miliola* lineage. His statement that the sides are "flat and slightly convex" is strong evidence that it is neither *Quinqueloculina* nor *Miliola*. Possibly, with its chamber arrangement, it should be placed in *Heterillina*.

The specimen figured by Cushman and McGlamery (1942) as *Quinqueloculina tessellata* is definitely a *Miliola*. However, it does not appear to have the flat sides described for Cushman's species (1922).

The specimens figured by Bergquist (1942) do not agree with his description of the species in which he quoted Cushman's original diagnosis verbatim. His Figure 11 on Plate 2 could be *Miliola byramensis*; Figure 14 on Plate 2 cannot be identified.

HETERILLINA Munier-Chalmas and Schlumberger, 1905

Heterillina MUNIER-CHALMAS and SCHLUMBERGER, 1905, Soc. Geol. France, Bull., (Ser. 4) vol. 5, p. 131

Tappanella ANDERSEN, 1984, Tulane Stud. Geol. Paleont., vol. 18, no. 1, p. 10; *non* GUIDINA and SUIDOVA, 1969, Doklady Akademii Nauk SSSR, vol. 185, no. 5, p. 1109-1111.

Helentappanella ANDERSEN, 1985, Micropaleontology, vol. 31, No. 1, p. 67.

Remarks: Andersen (1984, p. 10) made the following statement:

> "Both *Heterillina* and *Tappanella* have a massiline chamber arrangement; however, neither the description nor the illustrated specimen of *Heterillina* in Loeblich and Tappan's *Treatise on Foraminiferida* (1964, p. C470, fig. 357, 7a-c) accommodates *Tappanella punctatocostata* (Cushman) with its pitted chambers, costae, and perforated test."

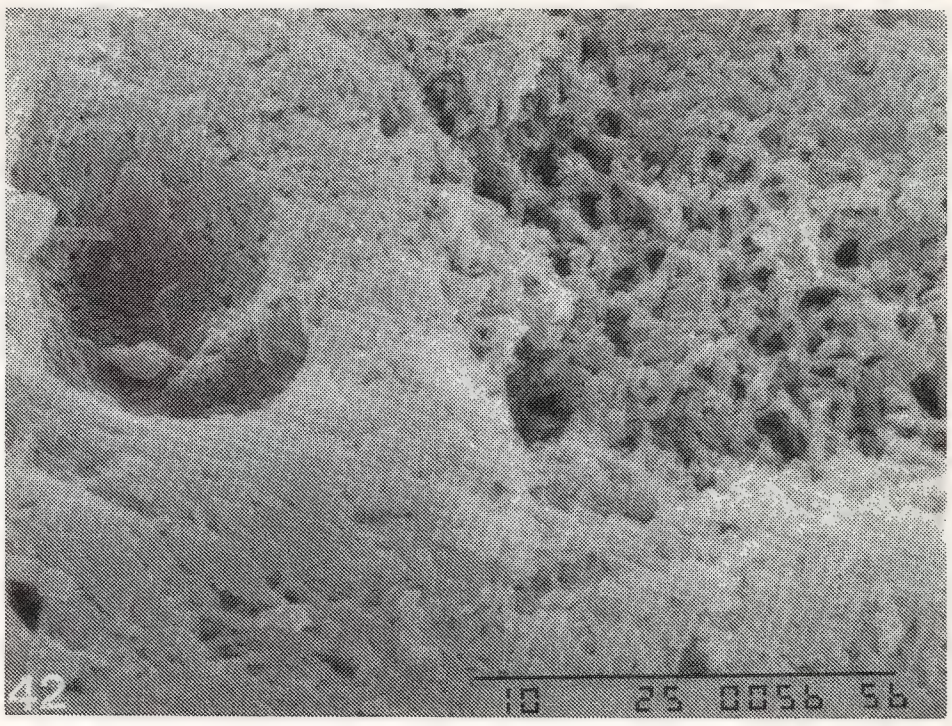


Figure 42. *Heterillina jacksonensis* (Cushman) showing the rodlike crystals of the middle layer.

The section herein on the Lutetian Miliolacea required a more thorough study of the foraminiferal literature from France than the paper written in 1984. Yolande Le Calvez (1970), in her study of the Paleogene foraminifers, described a species of *Heterillina* with a massiline chamber arrangement, costae, pits, and a cribrate aperture. Thus, Le Calvez is in agreement with Cushman, who designated the genotype of *Heterillina* in 1928. In his 1948 edition of *Foraminifera and their Economic Use* he states (p. 183), "This genus *(Heterellina)* has evidently developed from *Miliola*, as *Massilina* has come from *Quinqueloculina*." Also, a close examination of Loeblich and Tappan's Figure 357 (1964, p. C469), reproducing Munier-Chalmas and Schlumberger's original figure (1905), shows a transverse section of the chamber arrangement in *Heterillina*, in which every chamber on the exterior of the test has a serrated margin. These serrations have to indicate the presence of costae or pits; therefore, all available evidence leads to the conclusion that species attributed to *Heterillina*, an Eocene genus with costae and a cribrate aperture, must have pits on the wall of the test.

HETERELLINA JACKSONENSIS (Cushman)
Figure 32

Massilina jacksonensis CUSHMAN, 1927, Jour. Paleontology, vol. 1, p. 150, pl. 23, figs. 5, 6.
Quinqueloculina tuberculata CUSHMAN and TODD, 1945, Cushman Lab. Foram. Res., Contr., vol. 21, p. 81, pl. 13, fig. 17.
Tappanella jacksonensis (Cushman). ANDERSEN, 1984, Tulane Stud. Geol. Paleont., vol. 18, no. 1, p. 12, figs. 30-33.

Remarks: The calcium carbonate test of the single recovered specimen of this species, and that of all others from the Yazoo Formation in Little Stave Creek, Alabama, has been replaced with silica, which has altered the surface features. The pits are enlarged and are more irregularly shaped than those on specimens from the Moodys Branch Formation in Jackson, Mississippi. This single specimen is interpreted as megalospheric as the sides are only slightly convex.

Length of specimen No. 10,540 (Figure 32), 1.12 mm; width 0.78 mm.

Subfamily NEAGUITESINAE Andersen, 1984

NEAGUITES BYRAMENSIS (Cushman)
Figure 33

Spiroloculina byramensis CUSHMAN, 1922, U. S. Geol. Surv. Prof. Paper 129, p. 101, pl. 25, figs. 4a, b.
Neaguites byramensis (Cushman). ANDERSEN, 1984, Tulane Stud. Geol. Paleont., vol. 18, no. 1, p. 15, figs. 39, 40.

Remarks: This specimen has the closely interlocked perforations figured by Andersen (1984, fig. 40). During the early stages of weathering the "doughnut-shaped" structures form attached to the inner layer of the wall (see discussion in Part V).

Length of specimen No. 10,539 from the Red Bluff Formation (Figure 33), 0.40 mm; width 0.23 mm.

NEAGUITES sp. A

Description: Spiroloculine chamber arrangement; length slightly less than one and one-half times width; periphery carinate; neck extends beyond the penultimate chamber; surface of test smooth; one row of pits next to the carinate periphery aligned parallel to the chamber outline, the rest more-or-less randomly disposed and spaced two or three pit diameters apart; pores in each pit; aperture poorly preserved, probably cribrate. Length of specimen No. 10,541 from the Byram Formation type locality (Figure 34), 0.45 mm; width 0.33 mm.

Remarks: The planispiral chamber arrangement of this specimen satisfies the morphological requirements for the genus *Neaguites*, but the interlocking perforations on the test surface, the second most distinctive characteristic, are missing.

NEAGUITES DECORATUS (Cushman)
Figures 35-38

Massilina decorata CUSHMAN, 1922, U. S. Geol. Surv., Prof. Paper 129-F, p. 143, pl. 34, fig. 7; CUSHMAN, 1923, U. S. Geol. Surv., Prof. Paper 133, p. 55, 56; COLE and PONTON, 1930, Florida Geol. Surv., Bull. 5, pl. 10, fig. 5; HOWE and WALLACE, 1932, Louisiana Geol. Surv., Geol. Bull. 2, p. 20, 21, pl. 2, fig. 6; CUSHMAN, 1935, U. S. Geol. Surv., Prof. Paper 181, p. 13, pl. 3, figs. 14-16; CUSHMAN, 1939, Cushman Lab. Foram. Res., Contr., vol. 15, pt. 3, pl. 9, fig. 13; BERGQUIST, 1942, Mississippi Geol. Surv., Bull. 49, p. 22, pl. 10, fig. 26; C 1946, Cushman Lab. Foram. Res., Spec. Pub. 16, p. 5, 6; pl. 1, fig. 11; CUSHMAN and STONE, 1949, Cushman Lab. Foram. Res., Contr., vol. 25, pt. 4, p. 78, pl. 13, fig. 29; BANDY, 1949, Bulls. Amer. Paleontology, vol. 32, no. 131, pl. 2, figs. 7a, b; CUSHMAN, 1942, Cushman Lab. Foram. Res., Contr., vol. 5, pt. 2, p. 40, pl. 7, fig. 1.
Spiroloculina lamposa HUSSEY, 1949, Jour. Paleontology, vol. 23, pl. 26, fig. 6.
Neaguites lamposus (Hussey). ANDERSEN, 1984, Tulane Stud. Geol. Paleont., vol. 18, no. 1, p. 16, figs. 41, 42.

Remarks: Until 1984, with the exception of *Spiroloculina lamposa* Hussey, almost every small, smooth, flat-sided, spiroloculine specimen from the Eocene and Oligocene of the Gulf Coastal Plain, either with an exposed proloculus or with the proloculus concealed by the rotation of the initial coil, was identified as *Massilina decorata* Cushman. In 1984, Andersen introduced the genus *Neaguites* and referred these spiroloculine forms to *Neaguites lamposus*; here revised to *Neaguites decoratus* (Cushman).

In Cushman's original description, he described the sides of the test as "ornamented by very fine pits giving a granular appearance to the test." This writer examined specimens of this species from the Rosefield, Shubuta, and Red Bluff formations with the scanning electron micro-

scope. The electron photomicrographs (Figures 35-38) reveal that:

1) the test has a granular appearance due to weathering even in the best preserved specimens recovered;

2) the middle layer in the test wall consists of rodlike crystals loosely bound and randomly oriented similar to that of *Miliola saxorum* and "*Quinqueloculina*" *tuberculata*;

3) the "fine pits" perceived by Cushman with the binocular microscope were openings at the centers of "doughnut-shaped" elements, not present in any other genus of pitted Miliolacea studied; and,

4) In Figures 35, 36, and 37, the "doughnut-shaped" structures appear to be randomly distributed over the test surface, but in Figure 38, an enlarged section of the wall shows these structures to have a rational distribution pattern (see discussion in Part V).

The main purpose for examining specimens of *Neaguites decoratus* from a variety of localities was to verify the presence of the pits that must be present in this species as it has the three-layered test wall characteristic of the pitted *Miliola* lineage. The only observed "pits" are the holes at the center of the "doughnut-shaped" elements. Most were in clusters among the debris on the wall of the test and bore a single flange with the trace of a circle between the central hole and the perimeter of the element. In the lower left hand corner of Figure 38, the "doughnut-shaped" elements are: 1) somewhat uniformly distributed over wall of the test; 2) bear two unequal sized flanges with the upper smaller than the lower; and 3) have none of the rodlike crystals of the middle layer separating the two flanges. These two-flanged elements, the writer believes, are the original pits on the wall of the test weathered *in situ*. The two "doughnut-shaped" elements above the test in Figure 38 may be coccoliths in the weathered debris on the surface of the test. If not, then secondary deposition of calcite in the double-flanged elements caused coalescence of the two flanges with the outline of the upper flange superposed on the lower flange. After coalescence, the double-flanged "doughnut-shaped" structure becomes a coccolith-like element randomly dispersed within the debris on the surface of the test.

Neaguites decoratus differs from the type species of the genus, *Neaguites byramensis* (Figure 33), which has obvious pits that weather into flanged "doughnut-shaped" structures attached to the inner layer of the wall. As the "doughnut-shaped" elements are present on the weathered surface of *Neaguites lamposus* (Hussey), as shown by Andersen (1984, fig. 42), and because Hussey's type specimen strongly resembles *Neaguites decoratus*, it is considered a junior synonym of *Neaguites decoratus* (Cushman).

Figures 35 and 36 are from the Rosefield Formation (LSU GM 10,542); Figure 37 is from the Shubuta Formation (LSU GM 10,543); and Figure 38 is from the Red Bluff Formation (LSU GM 10,544).

V. DISCUSSION

The Enigmatic Knobs on Pitted Genera of Miliolacea

It has been demonstrated (see Figure 2), that *Miliola saxorum* (Lamarck) has a three-layered test wall. An electron photomicrograph of a slightly weathered specimen of "*Quinqueloculina*" *tuberculata* [=*Heterillina jacksonensis* (Cushman)] (see Figure 42), confirms the threefold subdivision of the wall in the *Miliola*-lineage, and more clearly depicts the structure and orientation of the calcite crystals in the wall of the test. Flat, interlocked crystals of calcite form the outer layer of the test and line the walls of the pits; a thick mass of short, rodlike, randomly oriented crystals forms the middle layer; and, though the inner layer is not visible in the electron photomicrograph, it is considered to be similar to the surface layer.

As the end product of weathering of the test wall is a series of knobs; differences in the material in the wall provide a residue of unweathered material that converts the pit into a knob. It is possible that the foraminifer concurrently secreted both ordinary calcite and magnesium-enriched calcite, with magnesium-free calcite deposited around the pits. This possibility may have been resolved by the work of Earl Manning, a graduate student at Louisiana State University, who has studied a foraminiferal assemblage from the

Holocene deposits off the coast of southeastern Nicaragua. He recovered a single specimen of "*Quinqueloculina*" *semireticulosa* Cushman from these deposits which was coated for electron microphotography. The coating, unfortunately, prevents determining the composition of the test. However, his results (see Figures 39-41) did reveal the three-layered structure of the pitted test wall, which has been shown to be present also in *Miliola saxorum* (compare Figures 41 with Figure 2), but with a greater number of perforations in the test than in the type species. Thus, his specimen should be placed in the genus *Miliola* and the range of the genus must be extended into the Holocene. Manning kindly granted permission to include his photographs in the plates (Figures 39-41).

A second possibility, favored by this writer, is that the formation of knobs can be attributed to the structure and orientation of the calcite crystals in the test wall. The loosely bound, rodlike crystals of the middle layer (see Figure 42) would be more readily dissolved or eroded, but the interlocked crystals of the outer and inner walls would be more resistant. In time, chemical and/or mechanical weathering could remove the outer and middle layers of the wall between the pits, but a few of the rodlike crystals from the middle layer weld the pit to the inner wall of the test, converting the pits into knobs. Concurrently or later, additional calcite could have been deposited in the pits enhancing the knobs. Laboratory washing procedures may affect the ornamentation and the weathered surface of the test. The nature or amount of such alteration is not known.

The presence of knobs has been noted in some species of pitted Miliolacea. Knobs characterize the species "*Quinqueloculina*" *tuberculata* Cushman and Todd from the Moodys Branch Formation at its type locality in Jackson, Mississippi. Doughnut-shaped structures characterize the species "*Massilina*" *decorata* Cushman, which occurs in almost every neritic foraminiferal assemblage in Louisiana, Mississippi, and Alabama sediments. Two questions are to be considered: 1) what set of circumstances produced the knobs; and, 2) are the "doughnut-shaped" structures the product of diagenetic alteration of the test wall.

The original description of "*Quinqueloculina*" *tuberculata* (Cushman and Todd, 1945) includes the following statement: "wall ornamented with raised knobs arranged in longitudinal rows, in well preserved specimens each knob having a pit on its summit and appearing to be perforated, in eroded specimens the knobs may be worn off leaving only rows of pits and faint longitudinal costae...This species is very distinctive with its striking raised ornamentation and should be a good index fossil for the Moodys marl." The above-quoted description stating that "knobs may be worn off leaving only rows of pits" is one of the principal reasons the present study was initiated. If their interpretation is correct, then erosion could convent knobs into pits on specimens of other species of Miliolacea.

Geological and Geographical Distribution of the Pitted Miliolacea

The distribution of the pitted Miliolacea, other than the genus *Neaguites*, remains essentially as described previously (Andersen, 1984). The oldest recognized genus, *Texina*, is reported only from the Claibornian (Middle Eocene) Weches Formation of Texas. A geologically younger, mature *Miliola* and *Heterillina* assemblage (see Table I) is present in the Moodys Branch Formation at Jackson, Mississippi, but is missing from the excellent and lithologically similar outcrop of Moodys Branch at Montgomery Landing, Grant Parish, Louisiana, and from the overlying Yazoo Formation.

During Upper Jacksonian (Upper Eocene) time, the pitted Miliolacea appear to have migrated southward into deeper water clastics as exposed at Little Stave Creek, Alabama, and eastward into the carbonate-rich deposits of the Ocala Group in Florida, where Puri (1957) reports *Miliola* in certain zones. The extent to which the pitted Miliolacea are present in the foraminiferal assemblages of Florida may never be fully recognized due to conditions unfavorable for good preservation of miliolid tests.

Oligocene pitted assemblages are best studied in the Bryam Formation of Mississippi where almost every known pitted Oligocene species is present (see Table I). Two pitted species, *Miliola byramensis* and *Miliola chipolensis* are reported from the Neogene of Florida. Thus, the range of the pitted Miliolacea extends into the Miocene, but no higher. No Holocene species with pitted tests are reported from the Gulf of Mexico area.

The genus *Neaguites* requires special consideration. It is distinguished by its planispiral coil, generally with the proloculus exposed on both flat sides of the test; the lack of a cribrate aperture; and its length which rarely exceeds 0.60 mm. *Neaguites decoratus* (Cushman) occurs in every Upper Jacksonian and Oligocene sample examined (see Table I), and in some samples, such as the Rosefield Formation in Louisiana, it is the dominant miliolacean in the assemblage. Only in the Byram and Red Bluff formations does *Neaguites* occur with an appreciable number of other miliolaceans.

The geological range of *Neaguites* extends from the Lower Jacksonian (Upper Eocene) through the Oligocene; its geographical distribution includes Louisiana, Mississippi, and Alabama. It has not been recorded from the Jacksonian of Florida. The morphological equivalent of *Neaguites*, but with an adventitious test and widely spaced pits is *Texina*, from the Weches Formation (Lower Eocene) of Texas.

Environmental Implications

The apparent environment in which most of the pitted Miliolacea thrived (attained their maximum growth), as previously reported by Andersen (1984, p. 18), is in warm, shallow water. Lending credence to this observation is the number of pitted species present in the Ocala Group (Eocene) of Florida, which certainly represented a warm, shallow water environment.

A problem which may have environmental implications, however, is the reduction in size and rare occurrence of the pitted Miliolacea in the Byram and Red Bluff formations. In these two Oligocene formation, most of the pitted Miliolacea are so small that only the largest individuals are retained on the 60 mesh sieve; so rare that one is most fortunate to recover a single specimen per tray of sample examined. Their association with pelagic foraminifera indicates that the depth environment has shifted from inner neritic waters at Jackson, Mississippi, to middle or outer neritic at Byram, Mississippi, a distance of only about 10 miles and covering a time span of millions of years. Either a shift in environment or advancing time has brought about the changes observed in the assemblages.

The time span of a species may result in reduction in size and/or distortion in the shape of the test. One specimen recovered from the Red Bluff Formation is identified as *Miliola* cf. *M. saxorum* (figure 19) on the basis of the distribution of the pits on the wall of the test. The specimen is small, slightly distorted, and has a length-width ratio greater than the norm for *M. saxorum*. If this species assignment is correct, this specimen could be regarded as evidence of senility in this species.

Time is considered the factor least likely to produce dwarf specimens in the Byram and Red Bluff formations. The many small members of these assemblages appear to be robust specimens of undescribed species or small representatives of large pitted forms which occur in the overlying Miocene strata. It is possible that the deeper water environment may have favored early maturity and reproduction, resulting in the small test size. In many species of foraminifera, it is known that very large individuals result from delayed reproduction, not from favorable environmental conditions.

Relationship of Gulf Coastal Plain and Paris Basin Miliolacea

Cushman's identification in 1935 of *Miliola saxorum* (Lamarck) from the Jackson Group of the Gulf Coastal Plain is correct. It is unequivocally the same as the Lamarck's species from the Paris Basin.

One group of foraminifera in the Lutetian, however, causes some concern–the small pitted forms with a length-width ratio of 3 or 4 to 1, which have isomorphs in the Gulf Coastal Plain. The specimens from Grignon and Damery, France, have a dis-

tinguishing feature in the keel on the distal end of the final chamber. One pitted specimen recovered from the Byram Formation appears to have this feature, but it is not observable in other specimens from the same sample because they were all fragmentary with the crucial portion of the test missing. Thus, *Miliola birostris* (Lamarck), or some other closely related species from the Paris Basin, may occur also in the Gulf Coastal Plain.

VI. ACKNOWLEDGMENTS

I wish to thank the following people for their contributions to this report: Dr. James Coleman, Chairman,, and Dr. Rex Pilger, Acting Chairman of the Louisiana State University School of Geology, for granting permission to use the School of Geology's scanning electron microscope; Ezat Atydari, LSU graduate student, for the excellent work he did in operating the microscope and processing the electron photomicrographs for this paper; Lewis Nichols for supplying needed materials; Dr. Clyde Moore, Jr., Professor of Geology at LSU, whose departmental support is appreciated; Alvin Phillips, Jr., curator of the LSU micropaleontology collections and library who supplied many of the samples and much pertinent literature not in my personal library; Earl Manning, LSU graduate student, who permitted me to publish three electron photomicrographs of a foraminiferan from his three electron photomicrographs of a foraminiferan from his master's thesis; and my partner, Harry L. Roland, Jr., who gave me a leave of absence to complete this report.

I again wish to express my appreciation to my friends and former students for the binocular microscope used in this study. Also, I especially wish to thank Dr. Willem van den Bold for the time spent in reviewing this paper.

VII. REFERENCES CITED

ANDERSEN, H. V., 1984, The wall structure of Superfamily Miliolacea and its lineage in the Gulf Coastal Plain: Tulane Stud. Geol. Paleont., vol. 18, no. 1, p. 1-19, 45 figs.

BANDY, ORVILLE L., 1949, Eocene and Oligocene Foraminifera from Little Stave Creek, Clarke County, Alabama: Bulls. Amer. Paleontology, vol. 32, no. 131, p. 1-147, 27 pls., 1 table.

BERGQUIST, HARLAN R., 1942, Scott County Fossils, Jackson Foraminifera and Ostracoda: Mississippi State Geol. Surv., Bull. 49, p. 1-146, 11 pls.

CUSHMAN, JOSEPH A., 1935, Upper Eocene Foraminifera of the Southeastern United States: U. S. Geol. Surv., Prof. Paper 181, p. 1-60, 23 pls.

CUSHMAN, JOSEPH A., 1948, Foraminifera: their classification and economic use: Fourth edition, revised and enlarged, with an illustrated key to the genera, Harvard Univ. Press, 605 pp., 55 pls.

CUSHMAN, JOSEPH A., and W. McGLAMERY, 1942, Oligocene Foraminifera near Millry, Alabama: U. S. Geol. Surv., Prof. Paper 197-B, p. 65-84, pls. 4-7.

HOWE, HENRY V., and WILLIAM E. WALLACE, 1932, Foraminifera of the Jackson Eocene at Danville Landing on the Ouachita, Catahoula Parish, Louisiana: Louisiana Geol. Surv., Geol. Bull. 2, p. 1-118, 15 pls.

KAASSCHIETER, JOHANNES P. H., 1961, Foraminifers of the Eocene of Belgium: Inst. Roy. Sci. Nat. Belgique, Memoir 147, 271 pp., 16 pls.

LE CALVEZ, YOLANDE, 1947, Revision des Foraminifères Lutetiens du Bassin de paris, I. Miliolidae: Mem. Expl. Carte Geol. det. France, pt. l, p. 1-45, 4 pls.

LE CALVEZ, YOLANDE, 1970, l'étude des Foraminifères Paléogènes du Bassin de Paris: Centre Natl. Recherche Sci., Paris, p. 1-326, 48 pls.

LOEBLICH, ALFRED R., JR., and HELEN TAPPAN, 1964, Treatise on Invertebrate Paleontology, Part C, Protista 2: Geol. Soc. America and Univ. Kansas Press, vol. 1, 510 pp., 399 figs.

LYS, MAURICE, and SAMUEL P. ELLISON, JR., 1965, Paris Basin, 1965 Geological Guide Book: Amer. Geol. Institute, 14 sections.

PURI, HARBANS S., 1957, Stratigraphy and zonation of the Ocala Group: Florida Geol. Surv., Bull. 38, pt. I - Stratigraphy, p. 17-89; pt. II - Foraminifera, p. 93-184, 15 pls.; pt. III - Ostracoda, p. 187-244, 15 pls.

TODD, M. RUTH, 1952, Vicksburg (Oligocene) smaller Foraminifera from Mississippi: U.S. Geol. Surv., Prof. Paper 241, 53 pp., 6 pls.

VEATCH, A. C., 1902, Notes on the Geology along the Ouachita: Louisiana State Univ. and A. and M. College, Spec. Report 4, p. 151-172, pls. 38, 39, figs. 14, 15.

Manuscript received December 30, 1985.

OSTRACODA OF ALACRAN REEF, CAMPECHE SHELF, MEXICO

W. A. VAN DEN BOLD

DEPARTMENT OF GEOLOGY
LOUISIANA STATE UNIVERSITY
BATON ROUGE, LOUISIANA

I. ABSTRACT

The ostracode fauna of the Alacran Reef, consisting of 105 species, exhibits a mixture of 1) reef genera (mostly Bairdiacea), 2) platform genera of the transition zone (calcareous platforms between the Caribbean and the Gulf of Mexico and Atlantic), 3) Caribbean, 4) Gulf of Mexico and 5) ubiquitous genera. Reef forms include: *Propontocypris*, *Paranesidea*, and ornate Bairdiidae. "Platform" genera include *Actinocythereis*, *Acuticythereis*, *Proteoconcha*, *Cytheretta*, and an abundance of *Loxoconcha (Loxocorniculum)*. Caribbean genera include *Gangamocytheridea* and *Quadracythere*. Gulf of Mexico genera include *Hulingsina*, *Peratocytheridea*, and *Loxoconcha*.

The reef slope and Campeche shelf typically harbour *Echinocythereis*, *Henryhowella*, *Cytheropteron*, *Pterygocythereis*, *Macrocyprina*, and *Paracytheridea*.

II. INTRODUCTION

The Alacran Reef is a shallow-water platform of approximately elliptical shape, with a long axis of 22 km in a NNW direction and a short axis of 12.5 km, situated about 150 km due north of Merida, Yucatan, Mexico (Text-fig. 1). It rises steeply from the Campeche Shelf, which is here about 56 m (170 ft.) deep (Kornicker and Boyd, 1962). In 1978, Dr. Kornicker, of the U.S. National Museum, sent me about 300 samples (washed residues) taken on and around the Alacran Reef. Some of this material was used for studies by graduate students of LSU, who identified species and tried to identify environments of sample-groups that were linked in cluster analysis. Unfortunatey, I do not have precise locations of all the samples (Text-fig. 1), and a number of them have been eliminated from this report. In the present study 43 samples have been used. They contained 105 ostracode species of which 77 could be identified with previously described species (63 in Table 1, 14 in explanation of Table 1). Two species are new but are not described here. The remaining species are listed as "sp." if they could be recognized as individual species (*e.g.*, *Paranesidea* sp.), the other are reported as "spp.," which include several species with scattered occurrences. Species that were found in only a single sample have not been tabulated (Table 1) but are listed in the explanation of Table 1.

The Alacaran Reef can be subdivided into a number of sub-environments from ENE to WSW: Windward Shelf; Windward Slope; Windward Reef-flat; Windward Trough; a broad expanse of topographic highs and lows that can be combined under the term "Cellular Reef deeps and highs" (Hoskin, 1968), and are here subdivided into "*Thalassia* patches, Patch Reefs, Cellular reef surface and Pinnacle Reefs" (Hoskin, 1966); Lagoon; Leeward Sand Flats; Leeward Slope; and Leeward Shelf. Foraminifera from seven samples from different environments were tabulated by Davis (1964). As these samples were not represented in the material received, no direct comparison can be made. Many of the species recorded here have been described in numerous publications, a list of which would unnecessarily lengthen the references. Therefore, I have indicated only those that are of direct importance to the present study. An alphabetical list of previously described species is attached as an Appendix.

III. ACKNOWLEDGMENTS

The type collection of ostracode species of the Gulf of Mexico that Dr. Rothwell donated to the H. V. Howe collection and his unpublished distribution charts of *Atlantis* cruise 1947, were widely used to ascertain bathymetric limitations of a number of species. The graduate students who

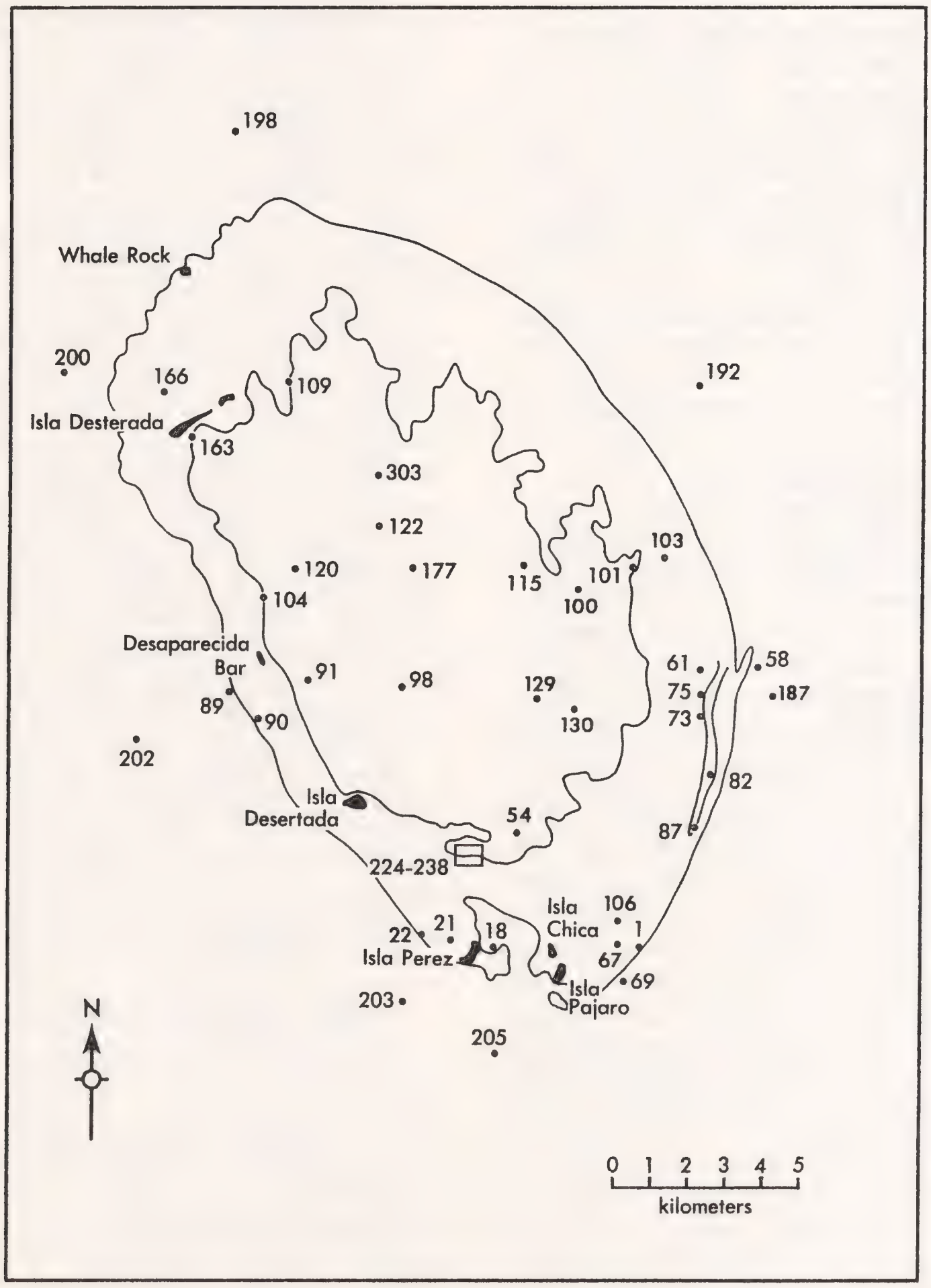
EDITORIAL COMMITTEE FOR THIS PAPER:
THOMAS CRONIN, United States Geological Survey, Reston, Virginia
MERVIN KONTROVITZ, Northwestern Louisiana University, Monroe, Louisiana
PAUL KRUTAK, Terra-Mar, Rye, Colorado

helped in this study were Kevin Kilmartin (Exxon Company, Houston), Gail Erlebacher (Amoco Production Company, New Orleans), Woodson Godfrey (Shell Oil Company, New Orleans) and Maria Luisa Machain (Instituto de Ciencias del Mar y Limnología, Mexico). Earl Manning studied foraminifera and ostracodes from the Nicaragua shelf for his master's thesis at LSU, Baton Rouge, and his results have been used for comparison. John B. Saunders (Naturhistorisches Museum, Basel, Switzerland) provided the comparative material from Buccoo Reef on Tobago (Trinidad and Tobago, W. I.).

IV. DISCUSSION

The Reef Fauna.

The fauna of the sediments within the reef proper is characterized by the large number of species of the Bairdiiae and Xestoleberididae. In addition, locally occurring in large numbers, are: *Proponotocypris, Macrocyprina, Radimella, Quadracythere, Jugosocythereis, Caudites, Acu-*



Text-fig. 1. Sample locations on and around the Alacran Reef. The location of samples 224, 231, 235, and 236 can be found in Hoskin (1966, fig. 5). A description of the reef topography can be found in Kornicker and Boyd (1962) and Hoskin (1968, fig. 1). The solid lines indicate the approximate extension of the reef surface and internal lagoon.

ticythereis, Proteoconcha, Loxoconcha (Loxocorniculum), Cytheretta, Cytherura, and *Paracytheridea.* As is to be expected, the majority of these are represented by the so-called "platform" species (occurring mainly in the transition zone between the Gulf of Mexico and the Caribbean, where carbonate platforms predominate from the Bahamas, through Cuba and southern Florida to Yucatan and Belize) (Bold 1978, Palacios-Fest *et al.*, 1985). To these belong: *Cytherella arostrata, Actinocythereis bahamensis, Acuticythereis laevissima, Proteoconcha tuberculata, Cytheretta pumicosa,* and species of *Loxoconcha (Loxocorniculum).*

Reef species are *Glyptobairdia coronata, Triebelina sertata, T. rugosa,* as well as other Bairdiidae (*e.g., Paranesidea bensoni).*

Caribbean species found on Alacran Reef include: *Paranesidea bradyi, Gangamocytheridea? plicata, Quadracythere producta, Orionina serrulatá.* Most Caribbean species occur only at rare instances (see explanation of Table 1, species marked with C).

Gulf of Mexico species include *Cytherella vermilionensis, Hulingsina tuberculata, Peratocytheridea bradyi, Caudites angulatus* and possibly *Loxoconcha wilberti.* (See also explanation of Table 1: species marked G).

There is a total absence of South American species, the most northerly occurrence of which appears to be in Belize.

Some species appear to have a restricted occurrence in the reef:

A: Shallow, agitated environment, *e.g.,* windward reef flat, shallow patchreefs, leeward sandflats: *Cytherelloidea* sp. B (in fact, most species of *Cytherelloidea), Bairdia longisetosa, Glyptobairdia coronata* (the occurrence at 95 feet, sample 51, Table 1, may be transported), *Morkhovenia inconspicua, Radimella confragosa, Caudites howei, Quadracythere producta, Hermanites hornibrooki.*

B: Deeper or more protected environment, *e.g., Thalassia* patches, cellular reef deeps, windward trough and lagoon: *Cytherella arostrata* (in fact, most species of *Cytherella), Propontocypris, Macrocyprina, Triebelina sertata, Acuticythereis laevissima, Pterygocythereis alophia, Radimella wantlandi. Keijia demissa* has been found only in the lagoon. Of course, many species actually living in the agitated environment will get swept into quieter places of the reef.

The fauna of the Alacran Reef shows similarity (55%, see Text-fig. 2) to that of the carbonate barrier rim and platform of the Belize shelf (Teeter, 1975). Teeter indicates that this environment is characterized by *Bairdia* and *Paranesidea, Triebelina, Glyptobairdia, Morkhovenia inconspicua, Orionina bradyi, Jugosocythereis pannosa, Cytheretta pumicosa, Cushmanidea cristifera, Loxoconcha wilberti, Loxoconcha (Loxocorniculum)* spp., *Hemicytherura bradyi, Paracytheridea* spp. and *Xestoleberis* spp. All these are present and often common to abundant on the Alacran Reef. *Cytherella arostrata, Triangulocypris laeva, Quadracythere producta* and some others are less restricted in their distribution in Belize. *Glyptobairdia, Triebelina, Loxoconcha (Loxocorniculum), Hemicytherura bradyi* and *Xestoleberis* are especially common in *Thalassia* patches on the Belize reef. For the Alacran Reef we may add *Havanardia sohni* to this restricted occurrence. Summarizing: Of the 102 species of Belize, 58 have been found on the Alacran Reef. The species not reaching Alacran are nearly all Caribbean forms (and especially South and Central American ones), and brackish water forms (totally absent on Alacran). The additional species found on Alacran Reef are Gulf of Mexico or platform species.

The ostracode fauna of the reef slope off northern Jamaica (Bold, 1978, Table 2) shows the presence of some reef and platform species (*Propontocypris* sp. 1 = *P. multiporifera, Macrocyprina* sp. aff. *M. maculata* = *M. propinqua*) and Caribbean species with almost total absence of Gulf of Mexico species (except *Triangulocypris laeva,* which may belong to the platform species) (53% Alacran species, see Text-fig. 2). Note among the platform species the absence of *Cytherella arostrata* and *Actinocythereis bahamensis.*

Comparison with the ostracodes of the Flower Garden Bank (Maddocks, 1974) shows that of the 34 species reported here, 14 occur on Alacran (41%, see Text-fig. 2). The Flower Garden fauna lacks Caribbean species and has only two platform species.

The Anton Lizardo reefs (Krutak, 1982)

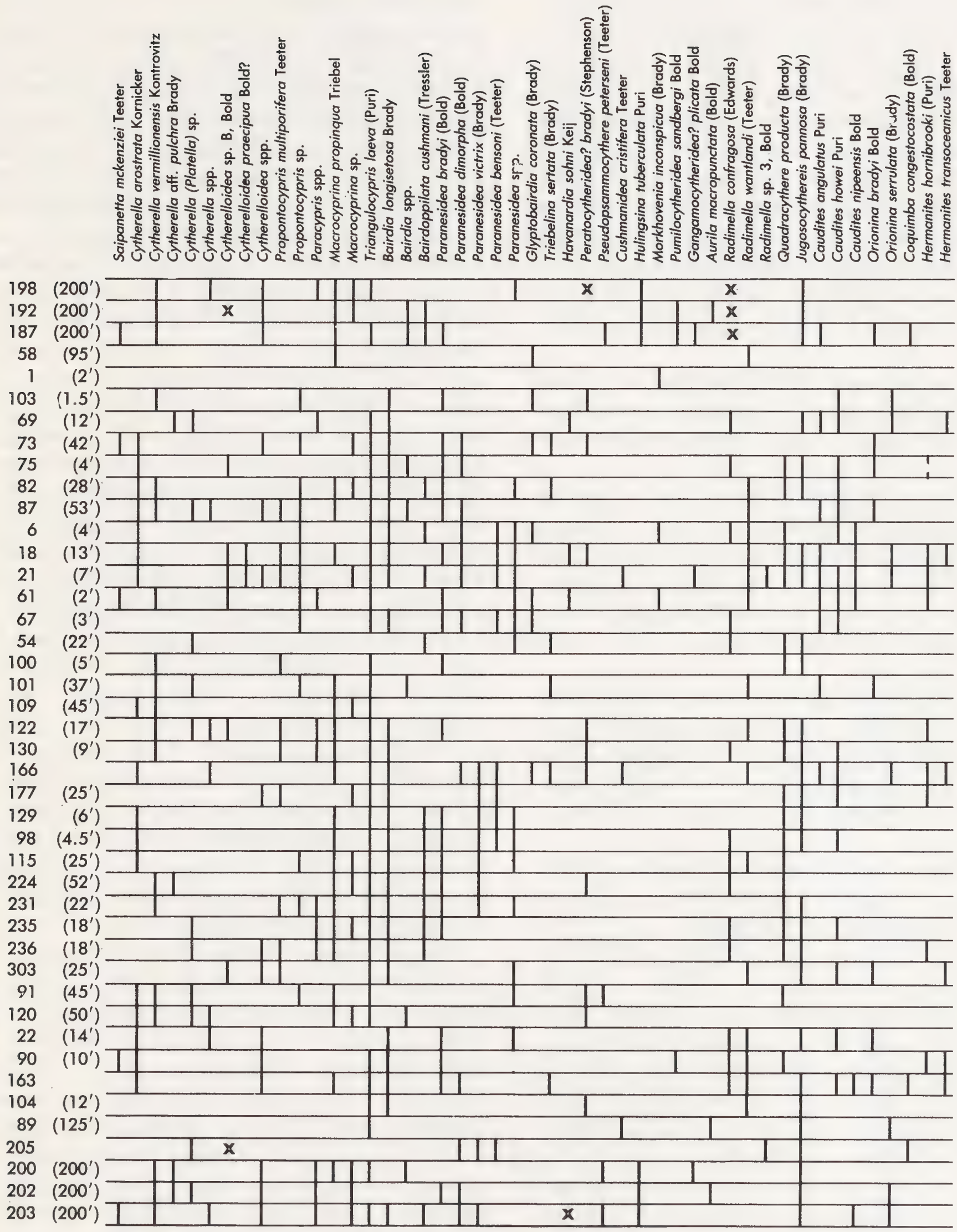
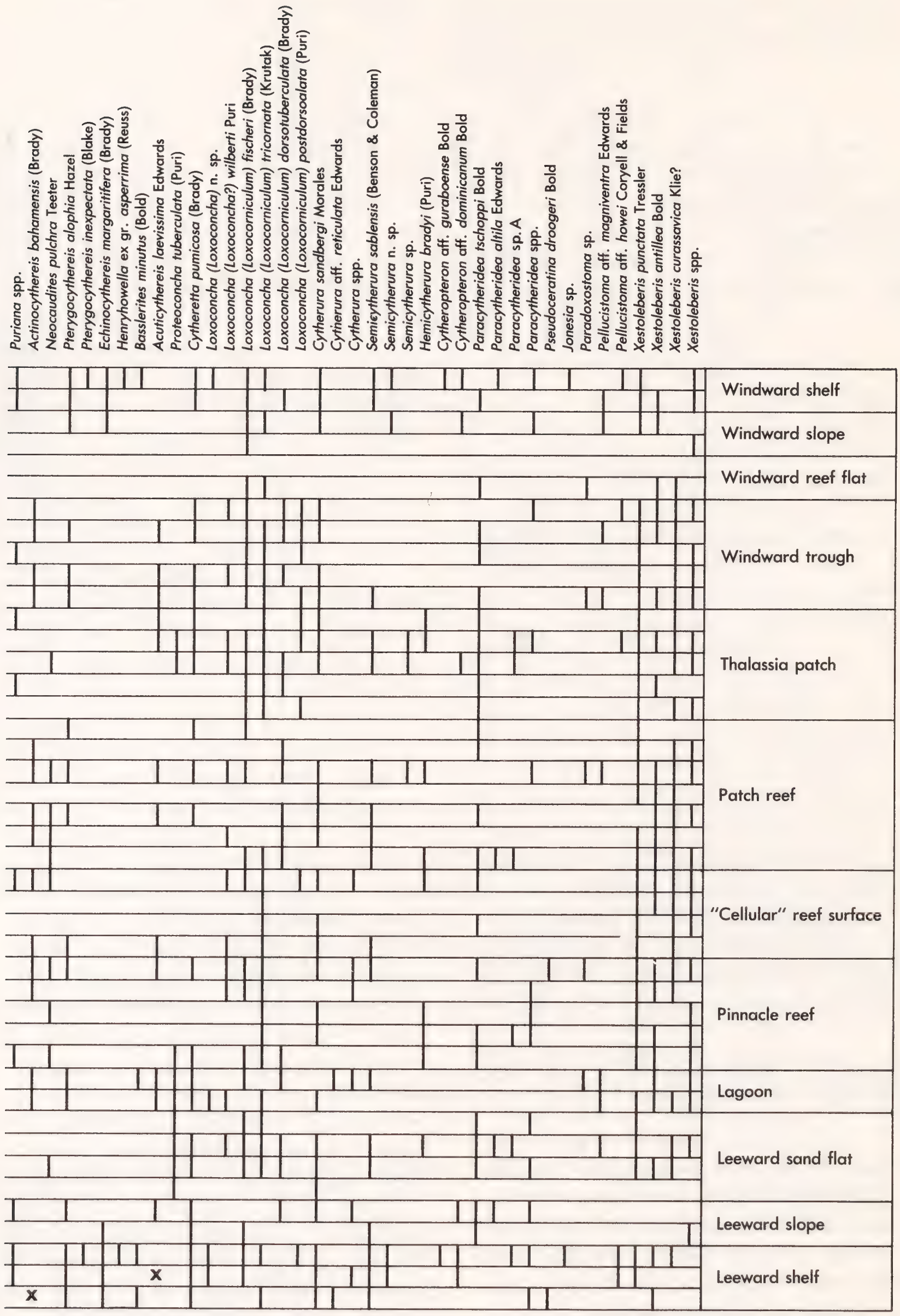


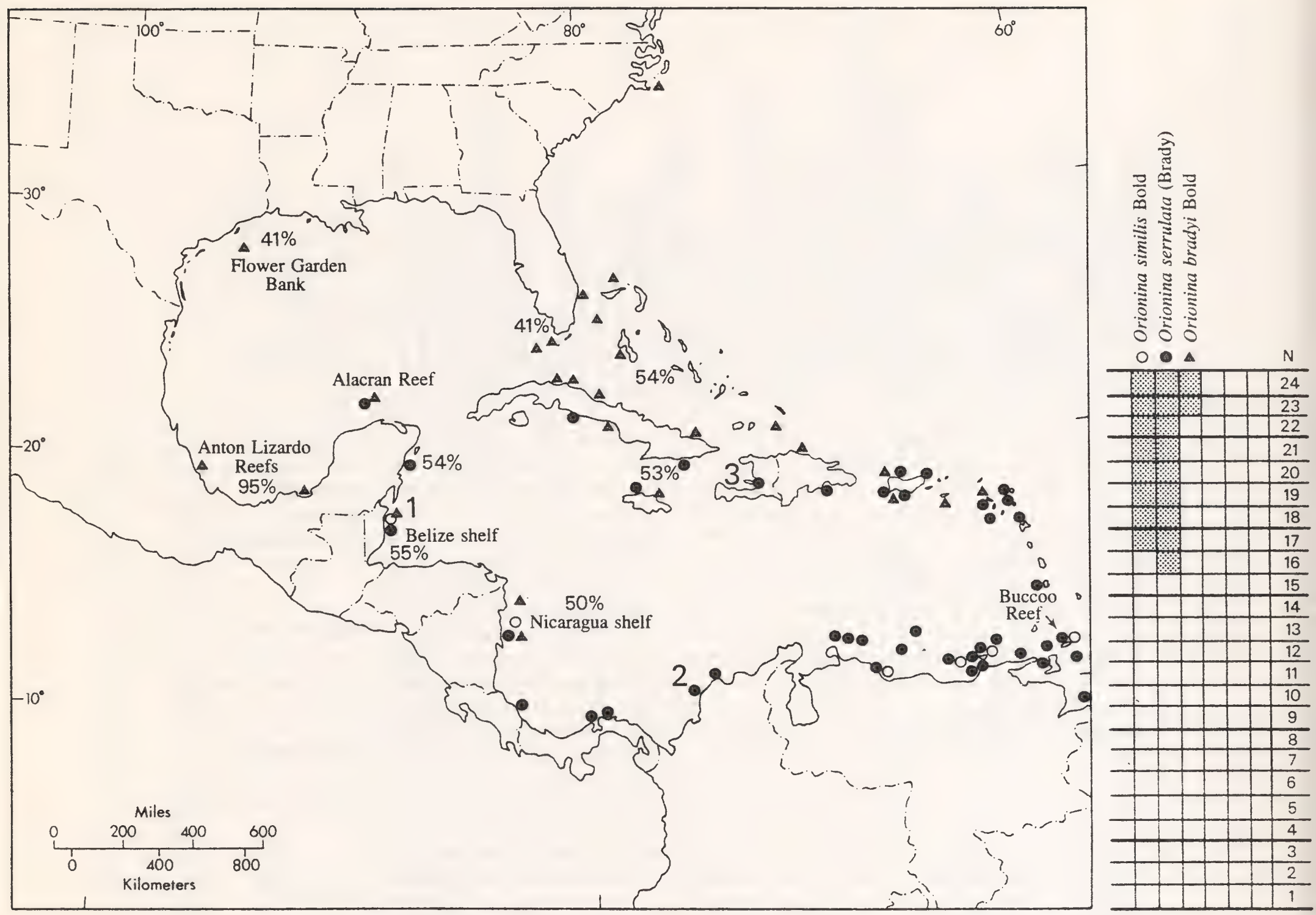
TABLE 1. Distribution of ostracodes across the Alacran Reef, Gulf of Mexico, omitting all species that were restricted to a single sample. Those not included in the table are: *Thalassocypris* sp. (187); *Aglaiocypris croneisi* Teeter (200); *Cytheromorpha apheles* Bold (166) C; *Pumilocytheridea alayai* Morales (21) G; *Keijia demissa* (Brady) (91) C; *Malzella evexa* Hazel (187) G; *Aurila auricula* (Teeter) (21) C; *Quadracythere lankfordi* Teeter (103) C; *Puriana convoluta* Teeter (82) C; *Caribella yoni* (Puri) (6); *Loxoconcha (Loxoconcha) avellana* Brady (187) C; *Phlyctocythere* sp. 2 (Bold, 1988) (192) C;



"*Monoceratina*" sp. (198); *Sclerochilus* sp. (200); *Kangarina depressa* Bold (177) C; *Microcythere howei* (Puri) (91); and *Microxestoleberis* sp. (163).

C = Caribbean form; G = Gulf of Mexico form. Numbers in parenthesis refer to localities in Text-fig. 1.

Species indicated by X on the distribution chart are believed to be transported.



Text-fig. 2. Distribution of Recent species of *Orionina*. Numbers refer to:
(1) Northernmost occurrence of *Costa variabilocostata recticostata* (South American fauna) and of *Reussicythere howei* (Central American fauna);
(2) Westernmost occurrence of "*Campylocythere*" *perieri* (South American fauna) and easternmost occurrence of *Reussicythere howei* (Central American fauna);
(3) Northernmost occurrence of "*Campylocythere*" *perieri* (South American fauna).

% indicates percentage of "Alacran" species of the total fauna
N refers to the N-zones of planktonic foraminiferal zonation.

of Veracruz, Mexico have a total of 22 species, 21 of which are in common with Alacran, 11 with Flower Garden. *Keijia demissa* occurs here, in Belize and Tobago (see comparison with Buccoo Reef), but only a few specimens have been found in the Alacran lagoon (loc. 91), and none on the the Flower Garden Bank.

Comparison of the Alacran and Belize faunas with those from the Nicaraguan shelf (1985) at water depth to 46.5 m, shows in the latter the almost complete absence of platform species: *Actinocythereis bahamensis, Cytherella arostrata, Cytheretta pumicosa* (only a few juveniles), *Acuticythereis, Proteoconcha*. The conspicuous absence of *Propontocypris multiporifera* may suggest that this species belongs rather to the reef fauna. *Macrocyprina propinqua* and *Triangulocypris laeva* are present. Fifty percent of the species also occur on the Alacran Reef. Compared with Belize there are also fewer Gulf of Mexico species; only *Caudites angulatus, Triangulocypris laeva* and *Loxoconcha wilberti* (the latter two may be platform species). On the other hand we find the (predictable) occurrence of widespread Caribbean species, some of which (*e.g., Cativella pulleyi* and *Loxoconcha spinoalata*) do not

occur at Alacran. Central American taxa, such as *Reussicythere howei* and *Ruggieria? dictyon*, which occur on both the Nicaraguan and Belize shelves, are also not reported from the Mexican Caribbean coast (Palacios-Fest, *et al.*, 1985) and apparently never reached the Yucatan channel (see Text-fig. 2). Simple percentages of species in common with the Alacran Reef show that all platform areas (Bahamas, Jamaica, Belize, Cozumel) share 53-55% of their species. The percentage drops to 50% on the Nicaraguan shelf and to 41% on the Florida West coast. The Nicaraguan and Belize shelves share 66% of their species. The Alacran fauna has 18 Caribbean species (of which 4 are very rare, and presumably just at the limit of their dispersal zone) and 14 species typical of the Gulf of Mexico fauna (*e.g.*, *Peratocytheridea? bradyi*, *Hulingsina tuberculata*).

In order to present a more complete overview of the relations of the platform faunas with those from the Gulf of Mexico and the Caribbean, an alphabetical listing of all taxa reported from the Alacran Reef, Mexican Caribbean coast (Cozumel) and the Belize and Nicaraguan shelves is given in Table 2; previously described species are listed in the Appendix.

A comparison with the ostracode fauna of the Buccoo Reef of Tobago gives interesting similarities and dissimilarities. Both contain *Propontocypris multiporifera* but the Buccoo reef has in addition *P. cantaraensis* (Pleistocene of Venezuela), different from the *P.* sp. of Alacran. Bairdiidae are less numerous than in Alacran or Belize, but include *Bairdia longisetosa*, *Paranesidea bradyi*, *P. bensoni*, *Triebelina sertata*, *T. rugosa*, *Glyptobairdia coronata* and *Havanardia sohni* (all reef species). *Pumilocythereidea sandbergi*, *Morkhovenia inconspicua*, *Caudites howei*, *C. nipeensis*, *Radimella*, *Puriana*, *Quadracythere producta*, *Basslerites minutus*, *Loxoconcha* ex gr. *postdorsoalata* and *Xestoleberis* (mostly *X. punctata*) are locally abundant on Buccoo Reef. The differences are the absence of platform genera such as *Actinocythereis*, *Acuticythereis*, *Proteoconcha* and *Cytheretta*, and the near absence of the *Loxoconcha (Loxocorniculum)* group [one occurrence of *L. (L.) fischeri*, a few rare ones of *L. (L.) tricornata*]. *Cytherella* is almost completely absent. *Paracytheridea* is represented by different species, as is *Cytherura (C. luciae*, a South American form).

In the Buccoo Reef we find *Gangamocytheridea? plicata*, *Cativella navis*, *Costa variabilocostata recticostata*, *Keijia demissa* and "*Campylocythere*" *perieri*, all South American or Caribbean forms, most of which are also reported from Belize (except "*C.*" *perieri*, see explanation Text-fig. 2).

Fauna of the Shelf and Reef Slope (Table 1).

The fauna of the reef slope and shelf around Alacran Reef is marked by the occurrence of *Echinocythereis margaritifera* (in the Gulf of Mexico from 31 - 470 - 1051 m water depth), *Hulingsina tuberculata* (2-104 m), *Henryhowella* ex gr. *asperrima* (41-3273 m), *Pterygocytheris inexpectata* (down to -230 m), *Cytheropteron* aff. *guraboense*, *Loxoconcha* n. sp. (31-±200 m), *Cytherura* n. sp. (in the Gulf of Mexico only present at 124 m and 335 m), as well as several of the species occurring on the reef, which are found downslope in greater numbers than could be accounted for by slope transport from the reef. These ubiquitous forms are: *Pterygocythereis alophia* (down to 230 m in the Gulf), *Cytheretta pumicosa* (down to 97 m), *Actinocythereis bahamensis* (-182 m), *Basslerites minutus* (31-105 m), *Macrocyprina propinqua* (-230 m), *Paracytheridea tschoppi* (-±200 m). Of all these, *Hulingsina* and *Pterygocythereis* are Gulf of Mexico forms, *Cytheretta pumicosa*, *Actinocythereis bahamensis* and possibly *Macrocyprina propinqua* are platform species. *Echinocythereis* and *Henryhowella* are widely distributed in deeper water, mainly outer continental shelf and continental slope.

Note on the Distribution of *Orionina* (Text-fig. 2)

The distribution of *Orionina serrulata* and *O. bradyi* was summarized by Bold (1978, p. 178-179, fig. 3) with *Orionina serrulata* as the typical Caribbean form, whereas *O. bradyi* occupies the northern fringes of the Antilles, the Bahama platform and the Gulf of Mexico. Some incon-

sistencies in this distribution were noted, where mixed populations of the two species occur. One of these was off northern Venezuela, one around Puerto Rico, the northernmost Lesser Antilles and Virgin Islands, and a third in Belize (Teeter, 1975). We can add to this the Nicaraguan shelf and the Alacran reef.

The material from around the islands of the coast of Venezuela was re-examined. It turned out that, wherever single valves of the supposed *O. bradyi* could be examined, the specimens had an indented line of concrescence and bunched radial porecanals; therefore, they are not *O. bradyi* but instead *O. similis* (Bold, 1963, p. 47, pl. 4, Fig. 7, 8, pl. 6, Fig. 8, 9). This species may be the same as *O. ebanksi* (Teeter, 1975, p. 488, Fig. 11 j-1, 12 b) and possibly also the same as *Orionina reticulata* (Hartmann) [*Cythereis (Elofsonella) reticulata* Hartmann, 1956, p. 37, Fig. 45-52, *Orionina reticulata* Hartmann, 1959, p. 240, pl. 58, Fig. 197-198)]. Note,

	Gulf	Alacran	Cozumel	Belize	Nicaragua	Caribbean
Cytheropteron (Lobosocytheropteron) barkeri				—		
Cytheropteron (Cytheropteron) aff. *dominicanum*	—	—		—		—
Cytheropteron (Cytheropteron) aff. *guraboense*	—	—		—		—
Cytheropteron (Cytheropteron) sp.	—	—	—	—	—	—
Cytherura aff. *cornuta*	—	—	—	—		—
Cytherura maya	—	—	—	—	—	—
Cytherura aff. *reticulata*	—	—		—		—
Cytherura sandbergi	—	—	—	—	—	—
Cytherura subwardensis	—	—	—	—		—
Cytherura swaini	—	—	—	—	—	—
Cytherura sp.	—	—	—	—	—	—
Dolerocypria inopinata	—	—	—	—		—
Echinocythereis margaritifera	—	—	—	—		—
Eucytherura aff. *complexa*	—	—	—	—	—	—
Eucytherura sp.	—	—	—	—	—	—
Gangamocytheridea? plicata	—	—	—	—	—	—
Glyptobairdia coronata	—	—	—	—	—	—
Glyptobairdia trinodosa	—	—	—	—	—	—
Havanardia havanensis	—	—	—	—		—
Havanardia sohni	—	—	—	—	—	—
Hemicyprideis kirkbyi	—	—	—	—		—
Hemicyprideis placentianensis	—	—	—	—		—
Hemicytherura bradyi	—	—	—	—	—	—
Hemicytherura cranekeyensis	—	—	—	—	—	—
Hemicytherura sp.	—	—	—	—	—	—
Henryhowella ex gr. *asperrima*	—	—	—	—	—	—
Hermanites hornibrooki	—	—	—	—	—	—
Hermanites transoceanicus	—	—	—	—	—	—
Hulingsina tuberculata	—	—	—	—	—	—
Jonesia sp.	—	—	—	—	—	—
Jugosocythereis pannosa	—	—	—	—	—	—
Kangarina ancyla	—	—	—	—	—	—
Kangarina depressa	—	--	—	—	—	—
Keijia demissa	—	--	—	—	—	—
Loxoconcha (Loxoconcha) avellana	—	--	—	—	—	—
Loxoconcha (Loxoconcha) levis	—	—	—	—	—	—
Loxoconcha (Loxoconcha) purisubrhomboidea	—	—	—	—	—	—
Loxoconcha (Loxoconcha) spinoalata	—	—	—	—	—	—
Loxoconcha (Loxoconcha) wilberti	—	—	—	—	—	—
Loxoconcha (Loxoconcha) n. sp.	—	—	—	—	—	—
Loxoconcha (Loxocorniculum) dorsotubercalata	—	—	—	—	—	—
Loxoconcha (Loxocorniculum) fischeri	—	—	—	—	—	—
Loxoconcha (Loxocorniculum) postdorsoalata	—	—	—	—	—	—
Loxoconcha (Loxocorniculum) tricornata	—	—	—	—	—	—

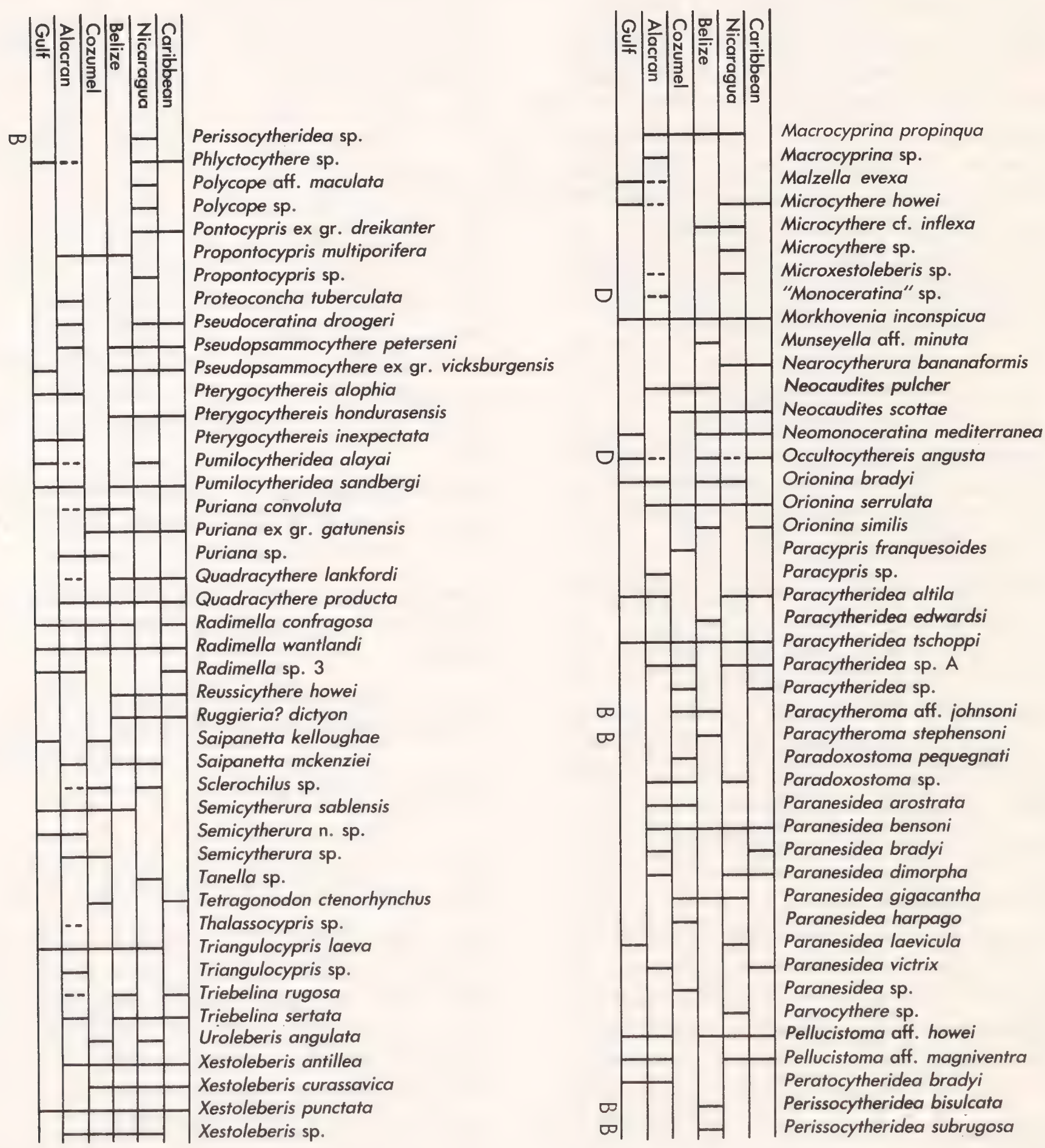
	Gulf	Alacran	Cozumel	Belize	Nicaragua	Caribbean
Actinocythereis bahamensis	—	—		—		
Acuticythereis laevissima		—				
Aglaiocypris croneisi		--	—	—		
Anchistrocheles bradyi			—			
Argilloecia sp.		--			—	
Aurila auricula		--	—	—	—	
Aurila chetumalensis				—		
Aurila macropunctata	—	—	—			—
Bairdia longisetosa	—	—	—	—	—	—
Bairdia dinochelata			—	—	—	
Bairdia sp.			—			
Bairdoppilata cushmani	—	—	—	—		—
Bairdoppilata fasciata				—		
Basslerites cuspidatus					—	
Basslerites minutus	—	—				—
Basslerites twincayensis				—		
Basslerites parvissima				—		
Callistocythere cranekeyensis	—			—		
Caribella puseyi				—	—	—
Caribella yoni	—	--		—	—	—
Caribella n. sp.					—	
Cativella pulleyi				—	—	—
Caudites angulatus	—	—		—		
Caudites highi			—	—	—	—
Caudites howei	—	—	—	—	—	—
Caudites nipeensis		—	—	—	—	—
Copytus baculoides			—	—	—	
Coquimba congestocostata		—			—	—
Costa variabilocostata recticostata				—	—	—
Cushmanidea cristifera		—	—	—	—	—
Cushmanidea sp.			—		—	
Cyprideis ovata			—	—		
Cytherella arostrata		—	—	—		
Cytherella harpago			—			
Cytherella pandorae				—	—	
Cytherella aff. *pulchra*		—				—
Cytherella vermillionensis	—	—		—		
Cytherella sp.		—	—		—	
Cytherelloidea aff. *leonensis*	—	—		—	—	
Cytherelloidea praecipua		—		—	—	—
Cytherelloidea sp. B		—		—	—	—
Cytherelloidea sp.			—		—	
Cytheretta pumicosa		—	—	—	--	
Cytheromorpha apheles		--		—	—	—

TABLE 2. Distribution of ostracodes in the area from Alacran reef, Cozumel (and Isla Mujeres), Belize and the Nicaragua shelf, compared to species that are typical for the Caribbean or for the Gulf of Mexico. The majority of species, which are restricted to this particular area and are not reported from the Gulf of Mexico or Caribbean, are platform

that the latter name is preoccupied by *Cythereis ornatissima reticulata* Jones and Hinde, 1889.

Re-examination of the material from the northern Lesser Antilles showed it to be correctly determined. Around Puerto Rico, Baker and Hulings (1966) reported many samples to contain *O. serrulata* and *O. bradyi*, both from the north and south sides of the island. In view of the fact that both species also occur together in a sample from Simpson Lagoon, St. Martin, this mixed distribution is accepted here.

On the Nicaragua shelf *O. serrulata* is somewhat more concentrated inshore, whereas *O. bradyi* occurs in offshore samples. Here also we find mixed populations. Teeter (1975) noted that in Belize *O. serrulata* (and *O. ebanksi* = *similis*?) occurs mainly in the main lagoon (and especially towards its southern end) and is extremely rare on the carbonate platform, whereas *O. bradyi* is restricted to the carbonate platform. Note that Palacios-Fest, *et al.*



species, except some deepwater forms (D) or brackish water forms (B). The distribution at Cozumel is taken from Palacios-Fest *et al.*, 1985; that at Belize from Teeter (1975); and that from the Nicaragua shelf from an unpublished master's thesis at L.S.U. by E. Manning (1985).

(1985) report only *O. serrulata* from the Cozumel-Isla Mujeres area.

On the Alacran Reef *O. bradyi* occurs mainly on the windward (ENE) side, but *O. serrulata* occurs mostly on the leeward (WSW) side. Although no mixed populations were found, there is one anomalous occurrence of *O. serrulata* inside the northern part of the reef (Fig. 1, loc. 166).

As *O. serrulata* shows up first in the early late Miocene in northern South America and Panama (Bold, 1964) and only in the Pliocene of the Greater Antilles, it might be classified as an originally South American species. The Alacran Reef appears to be its most northern Recent extension. *Orionina bradyi*, on the other hand, appears to be a southern North Atlantic form (Bermuda, Bahamas, U. S. Atlantic coast) and could possibly be related to the platform fauna. It has penetrated the Caribbean sea only at its northeastern end (Puerto Rico and Northern Lesser Antilles) and at its western end (south coast of Cuba, Nicaragua shelf and Belize).

V. CONCLUSIONS

Caribbean reef fauna: *Propontocypris multiporifera, Paranesidea bensoni, Triebelina sertata, T. rugosa, Glyptobairdia coronata, Havanardia sohni.*

Northwestern reefs: *Cytherella arostrata (Triangulocypris laeva?).*

Southeastern reefs: *Propontocypris cantaraensis, Triangulocypris keiji.*

Platform fauna: *Macrocyprina propinqua, Actinocythereis bahamensis, Acuticythereis laevissima, Proteoconcha tuberculata, Cytheretta pumicosa,* abundance of *Loxoconcha (Loxocorniculum)* spp. *(Triangulocypris laeva?, Loxoconcha wilberti?).*

Caribbean fauna: *Cativella pulleyi, C. navis, Quadracythere producta, Q. lankfordi, Gangamocytheridea? plicata, Cytherella polita, Orionina serrulata.*

Gulf of Mexico fauna: *Cytherella vermillionensis, Hulingsina tuberculata, Peratocytheridea bradyi, P. setipunctata, Caudites angulatus, (Triangulocypris laeva?, Loxoconcha wilberti?)*

Central American fauna: *Reussicythere howei, Pseudopsammocythere peterseni.*

South American fauna: "*Campylocythere*" *perieri, Costa variabilocostata recticostata.*

Outer shelf and outer slope: *Echinocythereis margaritifera, Henryhowella* ex gr. *asperrima.*

Ubiquitous shelf species: *Radimella* spp., *Caudites nipeensis, Hermanites hornibrooki, Puriana* spp., *Paracytheridea* spp., *Xestoleberis* spp.

VI. NOTES ON TAXONOMY

In order to keep the number of species at a practical level, only those species which could be identified with certainty have been tabulated (Table 1), if they occurred at more than one location. The ones with only a single occurence have been listed in the explanation of the table. After the identifiable species have been segregated, a small number of specimens are left, which cannot be assigned to any known species. They are often immature specimens, or are only rare occurrences. These have been indicated under the heading *Cytherella* spp., *Cytherelloidea* spp., etc.

A few of the species need some clarification.

Cytherelloidea sp. B (Bold, 1966) = *C. umbonata* Edwards of Teeter, 1975, not *C. umbonata* Edwards, 1944.

Bairdoppilata cushmani (Tressler) = *Bairdia* aff. *B. amygdaloides* Brady (Bold, 1978, table 3).

Aurila macropunctata (Bold, 1946) = *A. amygdala* (Stephenson) of Benson and Coleman (1963), not *Hemicythere amygdala* Stephenson, 1944.

Actinocythereis bahamensis (Brady) = *A.* aff. *A. bahamensis* (Brady) of Howe and Bold, 1975; = *A. subquadrata* Puri of Garbett and Maddocks, 1979; = sp. 35 of Rothwell, 1949 (H. V. Howe collection no. 6369, *Atlantis* cruise 1947, st. 363 at 70 m). Specimens of *A. subquadrata* Puri (1960) in the H. V. Howe collection are smaller and abraded. The present species is very common in samples of the Bahamas platform and, I believe, is identical with Brady's species, described in Les Fonds de la Mer (1870, p. 241, pl. 32, fig. 1, 2). It occurs in the Gulf of Mexico between 29 and 122 m (concentrated from 40-90 m).

Loxoconcha (Loxoconcha) n. sp. = types 9, 70 and ?94 of Rothwell (H. V. Howe collection no. 6327, station 73 of *Atlantis* 1947 cruise, waterdepth 80.5 m). It is a slightly punctate, tumid form with strongly compressed and smooth anterior and posterior margins. Its depth distribution in the Gulf of Mexico is from 31 - ±200 meters with a few isolated occurrences at greater depth.

Macrocyprina propiqua as used in this report comprises several species and should be replaced throughout by *Macrocyprina* sp. aff. *M. propinqua*.

Phlyctocythere sp. (explanation Table 1) (Alacran 291) = *Phlyctocythere* sp. 2 Bold (1988) of the Pliocene of the Dominican Republic = type 41 of Rothwell of the Gulf of Mexico (HVH no. 6357) station 75 at 80.5 m waterdepth.

Semicytherura n. sp. = type 109 of Rothwell, 1949. In the Gulf of Mexico it was found only as single specimens at stations 471 (335 m waterdepth) and 490 (124 m waterdepth) of *Atlantis* 1947 cruise.

Cytheropteron (Cytheropteron) aff. *dominicanum* Bold, 1988 = type 7 of Rothwell, 1949 (HVH no. 6325) station 74, at 73 m waterdepth. It is similar to *C.* (C.) *subreticulatum* Bold 1946, but smaller. It has been found at water depths ranging from 29 - 1317 m, most commonly 29-70 m.

Cytheropteron (Cytheropteron) aff. *guraboense* (Bold, 1988). Probably more than one species, some may be related to the *Lobosocytheropteron* group of *C. (L.) palton, C. (L.) barkeri* etc. Others may be identical to *C. guraboense*.

Paracytheridea sp. A, Bold, 1988, p. 63,pl. 11, fig. 3.

VII. LITERATURE CITED

BAKER, J. H., and N. C. HULINGS, 1966, Recent marine ostracod assemblages of Puerto Rico: Publ. Inst. Marine Science, Texas, vol. 11, p. 108-125.

BENSON, R. H., and G. L. COLEMAN, 1963, Recent marine ostracodes from the eastern Gulf of Mexico: University of Kansas, Paleontological Contributions, Arthropda 2, p. 1-52.

BOLD, W. A. VAN DEN, 1946, Contribution to the study of Ostracoda with special reference to the Tertiary and Cretaceous microfauna of the Caribbean Region. Dissertation, Rijksuniversiteit Utrecht, DeBussy, Amsterdam, 167 pp. Reprinted Antiquariat Junk, Lochem, Netherlands, 1970.

BOLD, W. A. VAN DEN, 1963, The ostracode genus *Orionina* and its species: Jour. Paleontology, vol. 37, no. 1, p. 33-50.

BOLD W. A. VAN DEN, 1966, Ostracoda from Colon Harbour, Panama: Caribbean Jour. Sci., vol. 6, no. 1, p. 43-53.

BOLD, W. A. VAN DEN, 1978, Distribution of marine Podocopid Ostracoda in the Gulf of Mexico and the Caribbean: Proc., 6th International Ostracod Symposium, 1976, p. 175-186.

BOLD, W. A. VAN DEN, 1988, Neogene Paleontology in the northern Dominican Republic, 7. The subclass Ostracoda (Arthropoda, Crustacea): Bulls. Amer. Paleontology, vol. 94, no. 34, p. 1-105.

BRADY, G. S., 1870, Description of Ostracoda, *in* DE FOLIN and PERIER, Les Fonds de la Mer, vol. 1, p. 177-256.

DAVIS, R. A., 1964, Foraminiferal assemblages of Alacran Reef, Campeche Bank, Mexico: Jour. Paleontology, vol. 38, no. 2, p. 417-421.

BARBETT, E. C., and R. F. MADDOCKS 1979, Zoogeography of Holocene Cytheracean Ostracodes in the bays of Texas: Jour. Paleontology, vol. 53, no. 4, p. 841-919.

HARTMANN, G., 1956, Weitere marinen Ostracoden aus Brasilien, *in* E. TITCHAK and H. W. KOEPEDE, Beiträge zur neotropischen Fauna, Fischer Verlag, Jena, p. 19-62.

HARTMANN, G., 1959, Zur Kenntnis der lotischen Lebensbereiche der pazifischen Küste von El Salvador unter besonderer Berücksichtigung seiner Ostracoden fauna: Kieler Meeresforschung, vol. 15, no. 2, p. 187-241.

HOSKIN, C. M., 1966, Coral pinnacle sedimentation, Alacran Reef Lagoon, Mexico: Jour. Sed. Pet., vol. 36, no. 4, p. 1058-1074.

HOSKIN, C. M., 1968, Magnesium and Strontium in mud fraction of Recent carbonate sediment, Alacran Reef, Mexico: Bull. Amer. Assoc. Petrol. Geol., vol. 52, no. 11, p. 2170-2177.

HOWE, H. V., and W. A. VAN DEN BOLD, 1975, Mudlump Ostracoda. Bulls. Amer. Paleontology, vol. 65, no. 282, p. 303-315.

KORNICKER, L. S., and D. W. BOYD, 1962, Shallow water geology and environments of Alacran Reef complex, Campeche, Mexico: Bull. Amer. Assoc. Petrol. Geol., vol. 46, no. 5, p. 640-673.

KRUTAK, P. R., 1971, The Recent Ostracoda of Laguna Mandinga, Veracruz, Mexico: Micropaleontology, vol. 17, no. 1, p. 1-30.

KRUTAK, P. R., 1982, Modern ostracodes of the Vera Cruz - Anton Lizardo reefs, Mexico: Micropaleontology, vol. 28, no. 3, p. 258-266.

KRUTAK, P. R., S. E. RICKLES and R. GIO-ARGAEZ, 1980, Modern ostracod species diversity, dominance and biofacies patterns, Vera Cruz - Anton Lizardo reefs, Mexico: Anales Centro Ciencias del Mar y Limnología, Universidad Nacional Autónoma, Mexico, vol. 7, no. 2, p. 181-198.

MADDOCKS, R. F., 1974. Ostracoda, *in* T. J. BRIGHT and L. H. PEQUEGNAT (edit.), Biota of the West Flower Garden Bank: Flower Garden Ocean Research Center, Marine Biomedical Institute, University of Texas Medical Branch at Galveston. Gulf Publishing Company, Houston, Texas, p. 201-213.

MANNING, E. M., 1985, Ecology of Recent foraminifera and ostracods of the continental shelf of southeastern Nicaragua: Thesis, Louisiana State University, Baton Rouge, LA, 460 pp.

PALACIOS-FEST, M. R., R. GIO-ARGAEZ, and P. R. KRUTAK, 1985, Los ostrácodos (Crustacea) recientes del Caribe Mexicano y su significación faunística: Anales Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma, Mexico, vol. 10, no. 1, p. 195-208.

ROTHWELL, W. T., 1949, Preliminary report on Ostracoda in bottom samples and cores of the northeastern Gulf of Mexico: Bull. Geol. Soc. Amer., vol. 60, no. 12, p. 1918 (abstract).

STEPHENSON, M. B., 1944, New Ostracoda from subsurface middle Tertiary strata of Texas: Jour. Paleontology, vol. 10, no. 2, p. 156-161.

TEETER, J. W., 1975, Distribution of Holocene Ostracoda from Belize, *in* K. F. WANTLAND and W. C. PUSEY, Belize shelf carbonate sediments, clastic sediments and ecology: Amer. Assoc. Petrol. Geol., Studies in Geology, vol. 2, p. 400-499.

APPENDIX

Alphabetical list of modern ostracodes in the Gulf of Mexico and Caribbean biogeographic provinces.

Actinocythereis bahamensis (Brady, 1870)
Acuticythereis laevissima Edwards, 1944
Aglaiocypris croneisi Teeter, 1975
Anchistrocheles bradyi Scott, 1905
Aurila auricula (Teeter, 1975)
Aurila chetumalensis Teeter, 1975
Aurila macropunctata (Bold, 1946)
Bairdia dinochelata Kornicker, 1961
Bairdia longisetosa Brady, 1902
Bairdoppilata cushmani (Tressler, 1941)
Bairdoppilata fasciata (Brady, 1870)
Basslerites cuspidatus Bold, 1966
Basslerites minutus Bold, 1958
Basslerites twincayensis Teeter, 1975
Basslerites parvissima Teeter, 1975
Callistocythere cranekeyensis Puri, 1960
"*Campylocythere*" *perieri* (Brady, 1868)
Caribella puseyi Teeter, 1975
Caribella yoni (Puri, 1960)
Cativella pulleyi Teeter, 1975
Caudites angulatus Puri, 1960
Caudites highi Teeter, 1975
Caudites howei Puri, 1960
Caudites nipeensis Bold, 1946
Copytus baculoides (Brady, 1890)
Coquimba congestocostata (Bold, 1963)
Costa variabilocostata recticostata Bold, 1970
Cushmanidea cristifera Teeter, 1975
Cyprideis ovata (Mincher, 1941)
Cytherella arostrata Kornicker, 1963
Cytherella harpago Kornicker, 1963
Cytherella pandorae Kornicker, 1963
Cytherella aff. *pulchra* Brady, 1866
Cytherella vermillionensis Kontrovitz, 1976
Cytherelloidea aff. *leonensis* Howe, 1934
Cytherelloidea praecipua Bold, 1963
Cytherelloidea sp. B Bold, 1966
Cytheretta pumicosa (Brady, 1866)
Cytheromorpha apheles Bold, 1963
Cytheropteron (Cytheropteron) aff. *dominicanum*Bold, 1988
Cytheropteron (Cytheropteron) aff. *guraboense* Bold, 1988
Cytheropteron (Lobosocytheropteron) barkeri Teeter, 1975
Cytherura aff. *cornuta* Brady, 1868
Cytherura lucinae Bold, 1966
Cytherura maya Teeter, 1975
Cytherura aff. *reticulata* Edwards, 1944
Cytherura sandbergi Morales, 1966
Cytherura subwardensis Teeter, 1975
Cytherura swaini Bold, 1963
Dolerocypria inopinata Klie, 1939
Echinocythereis margaritifera (Brady, 1866)
Eucytherura aff. *complexa* (Brady, 1866)
Gangamocytheridea? plicata Bold, 1968
Glyptobairdia coronata (Brady, 1870)
Glyptobairdia trinodosa Teeter, 1975
Havanardia havanensis Pokorý, 1968
Havanardia sohni Keij, 1976
Hemicyprideis kirkbyi (Brady, 1866)
Hemicyprideis placentiaensis (Teeter, 1975)
Hemicytherura bradyi (Puri, 1960)
Hemicytherura cranekeyensis Puri, 1960
Henryhowella ex gr. *asperima* (Reuss, 1850)
Hermanites hornibrooki (Puri, 1960)
Hermanites transoceanicus Teeter, 1975
Hulingsina tuberculata Puri, 1958
Jugosocythereis pannosa (Brady, 1869)
Kangarina ancyla Bold, 1963
Kangarina depressa Bold, 1968
Keijia demissa (Brady, 1868)
Loxoconcha (Loxoconcha) avellana (Brady, 1866)
Loxoconcha (Loxoconcha) levis Brady, 1870

Loxoconcha (Loxoconcha) purisubrhomboidea Edwards, 1954
Loxoconcha (Loxoconcha) spinoalata Bold, 1946
Loxoconcha (Loxoconcha) wilberti Puri, 1954
Loxoconcha (Loxocorniculum) dorsotuberculata (Brady, 186)
Loxoconcha (Loxocorniculum) fischeri (Brady, 1869)
Loxoconcha (Loxocorniculum) postdorsalata (Puri, 1960)
Loxoconcha (Loxocorniculum) tricornata (Krutak, 1971)
Macrocyprina propinqua Triebel, 1960
Malzella evexa Hazel, 1983
Microcythere howei (Puri, 1964)
Microcythere cf. *inflexa* Müller, 1894
Morkhovenia inconspicua (Brady, 1880)
Munseyella aff. *minuta* (Bold, 1946)
Nearocytherura bananaformis (Coryell and Fields, 1937)
Neocaudites pulcher Teeter, 1975
Neocaudites scottae Teeter, 1975
Neomonoceratina mediterranea (Ruggieri, 1953)
Occultocythereis angusta Bold, 1963
Orionina bradyi Bold, 1963
Orionina serrulata (Brady, 1869)
Orionina similis Bold, 1963
Paracypris franquesoides Swain, 1967
Paracytheridea altila Edwards, 1944
Paracytheridea edwardsi Teeter, 1944
Paracytheridea tschoppi Bold, 1946
Paracytheridea sp. A, Bold, 1988
Paracytheroma aff. *johnsoni* (Mincher, 1941)
Paracytheroma stephensoni (Puri, 1960)
Paradoxostoma pequegnati McKenzie, 1971
Paranesidea arostrata Kornicker, 1961
Paranesidea bensoni Teeter, 1975
Paranesidea bradyi (Bold, 1957)
Paranesidea dimorpha (Bold, 1963)
Paranesidea gigancantha (Kornicker, 1961)
Paranesidea harpago (Kornicker, 1961)
Paranesidea laevicula (Edwares, 1944)
Paranesidea victrix (Brady, 1869)
Pellucistoma aff. *howei* Coryell and Fields, 1937
Pellucistoma aff. *magniventra* Edwards, 1944
Peratocytheridea bradyi (Stephenson, 1938)
Peratocytheridea setipunctata (Brady, 1869)
Perissocytheridea bisulcata Teeter, 1975
Perissocytheridea subrugosa (Brady, 1870)
Phlyctocythere sp. 2, Bold, 1988
Polycope aff. *maculata* Müller, 1894
Pontocypris ex gr. *dreikanter* (Coryell and Fields, 1937)
Propontocypris cantaraensis Bold, 1972
Propontocypris multiporifera Teeter, 1975
Proteoconcha tuberculata (Puri, 1960)
Pseudoceratina droogeri Bold, 1965
Pseudopsammocythere peterseni (Teeter, 1980)
Pseudopsammocythere ex gr. *vicksburgensis* (Howe and Law, 1936)
Pterygocythereis alophia Hazel, 1983
Pterygocythereis hondurasensis Teeter, 1975
Pterygocythereis inexpectata (Blake, 1929)
Pumilocytheridea alayai Morales, 1966
Pumilocytheridea sandbergi Bold, 1963
Puriana convoluta Teeter, 1975
Puriana ex gr. *gatunensis* (Coryell and Fields, 1937)
Quadracythere lankfordi Teeter, 1975
Quadracythere producta (Brady, 1866)
Radimella confragosa (Edwards, 1944)
Radimella wantlandi (Teeter, 1975)
Radimella sp. 3, Bold, 1975
Reussicythere howei Bold, 1983
Ruggieria? dictyon Bold, 1966
Saipanetta kelloughae Maddocks, 1972
Saipanetta mckenziei Teeter, 1975
Semicytherura sablensis (Benson and Coleman, 1963)
Tetragonodon ctenorhynchus (Brady, 1887)
Triangulocypris laeva (Puri, 1960)
Triebelina rugosa Allison and Holden, 1971
Triebelina sertata Triebel, 1948
Uroleberis angulata (Brady, 1870)
Xestoleberis antillea Bold, 1988
Xestoleberis curassavica Klie, 1939
Xestoleberis punctata Tressler, 1949

October 12, 1988

REVIEW

HANDBOOK OF PALEOZOOLOGY, by Emil Kuhn-Schnyder and Hans Rieber; translated by Emil Kucera. Published by The Johns Hopkins University Press, Baltimore and London, 1987, a volume in the series Johns Hopkins Studies in Earth and Planetary Sciences, xiii + 394 pp., illustrated, index, $32.50

This work, originally published in German (1984), was designed to provide students with a greatly condensed but well-illustrated introduction to the systematics of fossil animals. As the known fossil forms are so abundant and diverse, the treatment of fossil animals in this book was of necessity selective and subjective. Thus, even though both the invertebrates and

the vertebrates are included, the work does encompass the major important groups in a single volume.

The principal utility of the fossil record is as a "tool" or method used by geoscientists to interpret the past history of the Earth through geological time. The work of establishing a chronological framework for Earth history is based largely on the invertebrate animal fossils which were preserved in countless numbers in the marine sedimentary rocks of the Earth's crust. Thus, invertebrate fossils are of primary interest to geoscientists. This observer considers the one hundred forty-seven pages devoted to the invertebrates to be so abbreviated that this portion of the work is totally inadequate for the student reference volume intended. The two hundred and twelve pages allocated to the Chordata, a single phylum, are more nearly adequate, though the average reader/user may find the treatment of dinosaurs far too brief. However, the book may be useful as a reference volume for the layman or nonbiologist.

The classification of fossil animals must be based on preservable morphological characteristics and, further, is burdened by the imperfection and incompleteness of the fossil record. Thus, most taxonomic groups are classified by their skeletal features, and those ancient forms lacking skeletons are generally unknown. A few exceptions such as stromatolites and organic-walled microfossils are commonly found preserved, but most ancient soft-bodied organisms have left no known fossil record. At a very few localities fortuitous preservation has occurred, providing fleeting glimpses of past soft-bodied life, but generally our knowledge of such forms is fragmentary or lacking. The result is that a work such as this must deal with preserved fossil organisms and with classifications based on skeletal features alone, though comparisons with living forms can be made. These limitations make a coherent and comprehensive compilation difficult.

There are some inconsistencies noted. The authors chose to place the Protozoa in the Kingdom Animalia as a subphylum, thus rejecting the Kingdom Protista to which most micro-organisms are referred by modern micropaleontologists. Thus, rhizopods (foraminifers, radiolarians, etc.), coccoliths, silicoflagellates, dinoflagellates, ciliates, acritarchs, and other nannofossils are placed in the Animalia. However, calpionellids are listed under the heading "Protista incertae sedis" at the end of the section on Protozoa!

In the classification of the multicellular animals, the Archeocyatha, Conodonta, and Onychophora are given separate phylum-level status; this is appropriate. However, the authors use the unfamiliar heading, Division Eumetazoa. In this "division" the Brachiopoda and the Bryozoa are placed alongside the Phoronida as separate classes within the Phylum Tentaculata in the Subdivision Bilateria; the coelenterates are listed as the Phylum Cnidaria, the only phylum in the Subdivision Coelenterata. This is awkward, confusing and unnecessary. The classification headings and subheadings for the phyla Mollusca, Annelida, Onychophora, Arthropoda, Echinodermata, and Hemichordata are acceptable, but the unnecessary insertion of "Group of Phyla Articulata" between the Mollusca and the succeeding phyla is burdensome. In the Chordata, the greater interest and bias of the authors becomes apparent. There are useful explanatory sections inserted, such as: an introductory explanation of vertebrate terminology and taxonomy, "Conquest of the Land–The Tetrapods", and "Transition from Reptiles to Mammals". This makes the vertebrate section of the book much more useful.

This volume will be useful only to the lay reader who needs general information about fossil forms; the student who has some experience in paleobiology, professional paleobiologists, and geoscientists will find it inadequate.

—H.C.S.

TULANE STUDIES IN GEOLOGY

VOLUME 1, Complete with title page and contents $7.00

VOLUME 2, Complete with title page and contents $7.00

VOLUME 3, Complete with title page and contents $10.00

VOLUME 4, Complete with title page and contents $10.00

VOLUME 5, Complete with title page and contents $10.00

VOLUME 6, Complete with title page and contents $10.00

TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

VOLUME 7, Complete with title page and contents $12.00

VOLUME 8, Complete with title page and contents $12.00

VOLUME 9, Complete with title page and contents $12.00

VOLUME 10, Complete with title page and contents $15.00

VOLUME 11, Complete with title page and contents $15.00

VOLUME 12, Complete with title page and contents $15.00

VOLUME 13, Complete with title page and contents $15.00

VOLUME 14, Complete with title page and contents $18.00

VOLUME 15, Complete with title page and contents $18.00

VOLUME 16, Complete with title page and contents $18.00

VOLUME 17, Complete with title page and contents $20.00

VOLUME 18, Complete with title page and contents $20.00

(see earlier issues for individual listing)

Vol. 19, Nos. 1, 2. THE CALCAREOUS NANNOPLANKTON OF THE MIDWAY GROUP (PALEOCENE) OF ALABAMA, by David Reimers; TAPHONOMIC CHARACTERISTICS OF OFFSHORE MOLLUSK SHELLS, SAPELO ISLAND, GEORGIA, by Robert W. Frey and James D. Howard; AN EVALUATION OF THE TAXA *MURICOPSIS* AND *RISOMUREX* (GASTROPODA:MURICIDAE), WITH ONE NEW SPECIES OF *RISOMUREX* and A NEW SPECIES OF *MURICOPSIS (RISOMUREX)* FROM WEST AFRICA, by Emily H. Vokes and Roland Houart; NEW SPECIES OF *BATHYSIPHON* (FORAMINIFERIDA:TEXTULARIINA) FROM FRANCISCAN FLYSCH DEPOSITS, NORTHERNMOST CALIFORNIA, by William Miller, III; PUBLICATION DATES OF HEILPRIN'S EXPLORATIONS ON THE WEST COAST OF FLORIDA, by Richard E. Petit and Druid Wilson, pp. 1-96 (July 31, 1986)– BOUND TOGETHER. $12.00

Vol. 19, Nos. 3, 4. COMMUNITY REPLACEMENT IN ESTUARINE PLEISTOCENE DEPOSITS OF EASTERN NORTH CAROLINA, by William Miller, III; OSTRACODE BIOSTRATIGRAPHY AND PALEOECOLOGY OF THE PLIOCENE OF THE ISTHMIAN SALT BASIN, VERACRUZ, MEXICO, by Maria L. Machain-Castillo; FRESH AND BRACKISH WATER OSTRACODA FROM THE NEOGENE OF NORTHERN VENEZUELA, by W. A. van den Bold; MYTILIDAE (MOLLUSCA:BIVALVIA) FROM THE CHIPOLA FORMATION, LOWER MIOCENE, FLORIDA and AN UNUSUAL DISTORTED *SPONDYLUS* FROM THE MOIN FORMATION (PLEISTOCENE), COSTA RICA, by Harold E. Vokes; NOTES ON THE FAUNA OF THE CHIPOLA FORMATION-XXX: ON THE PRESENCE OF *EUDOLIUM (GALEODOLIUM) SUBFASCIATUM* SACCO (GASTROPODA:TONNIDAE), by Emily H. Vokes; EARLY PLIOCENE *MONTFORTELLA* (FORAMINIFERIDA) FROM ECUADOR, by Drew Haman and Barry Kohl; *KARRERIELLA OBTURACULOIDES*, A NEW AGGLUTINATED BENTHIC FORAMINIFERAL SPECIES and *AMPLECTODUCTINA*, A NEW FORAMINIFERAL GENUS, IN THE SIPHOGENERINODIDAE, by R. Timothy Patterson; pp. 97-191 (December 15, 1986) – BOUND TOGETHER $12.00

VOLUME 19, Complete with title page and contents $20.00

Vol. 20, Nos. 1-3. LATE MIOCENE AND EARLY PLIOCENE SILICEOUS MICROFOSSILS FROM THE UPPER MONTEREY AND LOWER SISQUOC FORMATIONS, SWEENY ROAD, SANTA BARBARA COUNTY, CALIFORNIA, by W. H. Akers, R. E. Marolt, and R. J. Navarette; pp. 1-112 (September 16, 1987) – BOUND TOGETHER. $15.00

Vol. 20, 4. TAXONOMIC INDEX TO VOLUMES 11 THROUGH 20, by Emily H. Vokes; pp. 113-200 (December 31, 1987). $5.00

VOLUME 20, complete with title page and contents $20.00

Vol. 21, Nos. 1, 2. MURICIDAE (MOLLUSCA:GASTROPODA) OF THE ESMERALDAS BEDS, NORTHWESTERN ECUADOR, by Emily H. Vokes; PLIOCENE EPITONIIDAE OF THE ESMERALDAS BEDS, NORTHWESTERN ECUADOR (MOLLUSCA:GASTROPODA), by Helen DuShane; AGE AND STRATIGRAPHIC CORRELATION OF THE RAYSOR FORMATION, LATE PLIOCENE, SOUTH CAROLINA, by Lauck W. Ward and Paul F. Huddleston; OLIGOHALINE FOSSILS FROM THE PLEISTOCENE FLANNER BEACH FORMATION, NORTH CAROLINA and GIANT AGGLUTINATED FORAMINIFERIDS FROM FRANCISCAN TURBIDITES AT REDWOOD CREEK, NORTHWESTERN CALIFORNIA, WITH THE DESCRIPTION OF A NEW SPECIES OF *BATHYSIPHON*, by William Miller III: pp. 1-84 (July 20, 1988) – BOUND TOGETHER. . . $12.00

VOLUME 21, complete with title page and contents $20.00

VOLUME 22, Subscription $20.00

SMITHSONIAN INSTITUTION LIBRARIES

SMITHSONIAN INSTITUTION LIBRARIES

SMITHSONIAN INSTITUTION LIBRARIES
3 9088 01276 3645